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Ohtsuki et al.

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[45] Date of Patent: Aug. 11, 1998

[54] **SUSPENSION SUPPORT DEVICE FOR AN OUTER WALL WORKING MACHINE**

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[73] Assignee: **Nihon Biso Co., Ltd.**, Japan

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[51] **Int. Cl.**[6] **A47L 1/02**

[52] **U.S. Cl.** **414/663**; 15/103; 414/633

[58] **Field of Search** 15/103; 414/10, 414/11, 630, 631, 633, 637, 662, 663, 744.2, 744.5

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,497,902	3/1970	Hartigan	15/103 X
3,803,656	4/1974	Fannon, Jr.	15/302

FOREIGN PATENT DOCUMENTS

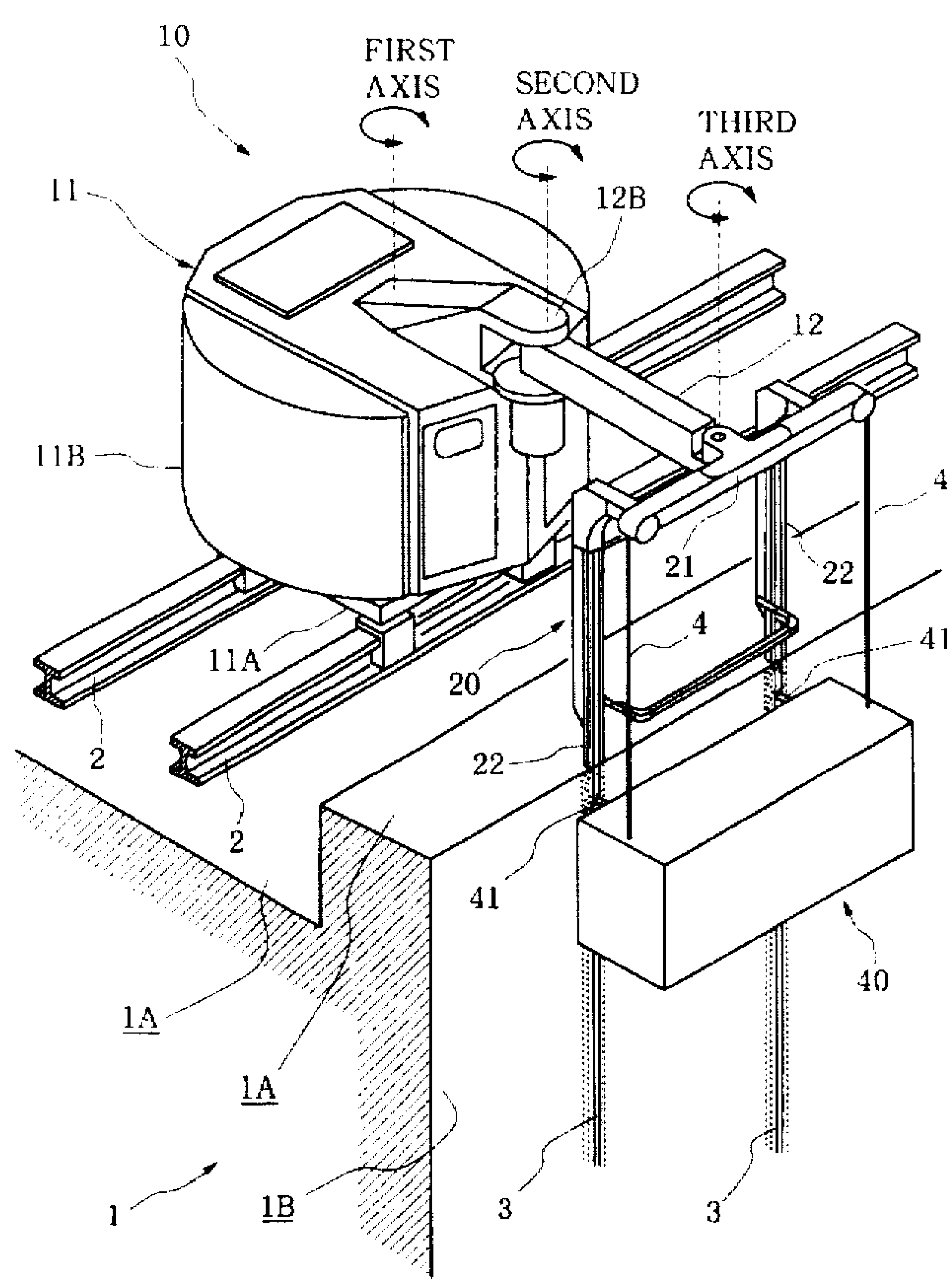
1428414	3/1969	Germany .	
4404797	8/1995	Germany .	
4423797	1/1996	Germany .	
53-135173	11/1978	Japan	15/103
1557640	12/1979	United Kingdom .	

Primary Examiner—Janice L. Krizek
Attorney, Agent, or Firm—Hedman, Gibson & Costigan, P.C.

[57] **ABSTRACT**

A suspension support device is provided movably on the upper surface of a building for suspending, by means of ropes, an outer wall working machine having fitting and moving members which can be fittedly engaged in a pair of guide grooves formed vertically on an outer wall surface of the building, and lowering and lifting the outer wall working machine along the guide grooves. The device includes a main body, an arm structure connected to the main body, a holding unit connected to the arm structure in a manner to be movable forwardly and rearwardly, laterally and pivotably about a vertical axis and including a pair of holding guides provided at an interval equal to an interval of the pair of guide grooves and being capable of receiving the fitting and moving members, an arm structure drive unit for driving the arm structure to move the holding unit, sensors for detecting the upper edge of the building, and a drive control system for controlling driving of the arm structure drive unit in response to detection information supplied by the sensors. The drive control system controls driving of the arm structure in response to detection information supplied by the sensors to move the holding unit to a position at which the holding guides align with the guide grooves.

3 Claims, 16 Drawing Sheets



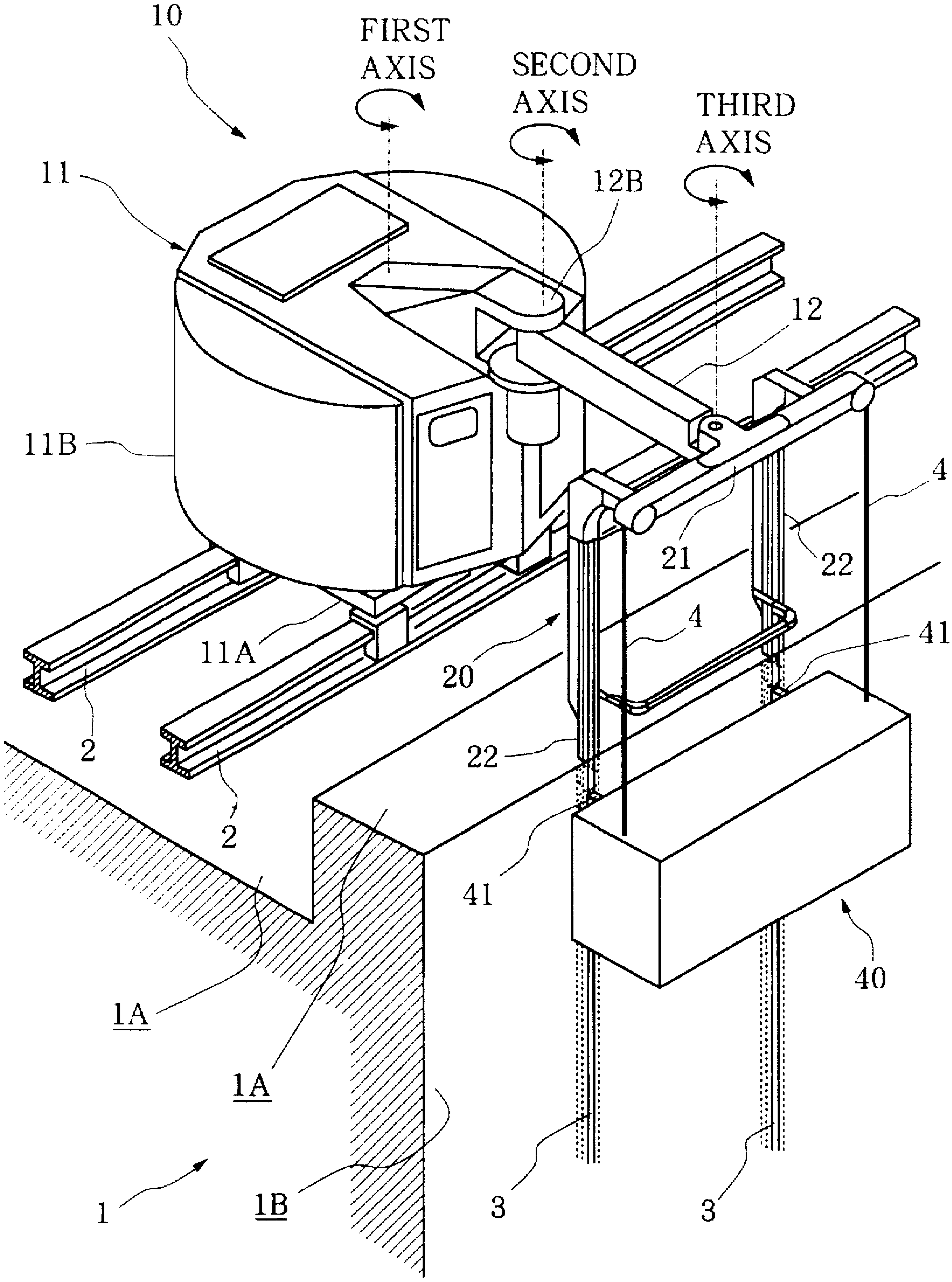

10
FIRST AXIS
SECOND AXIS
THIRD AXIS
11
12B
12
11B
4
21
22
4
41
11A
20
2
22
2
41
40
1A
1A
1
1B
3
3

FIG. 1

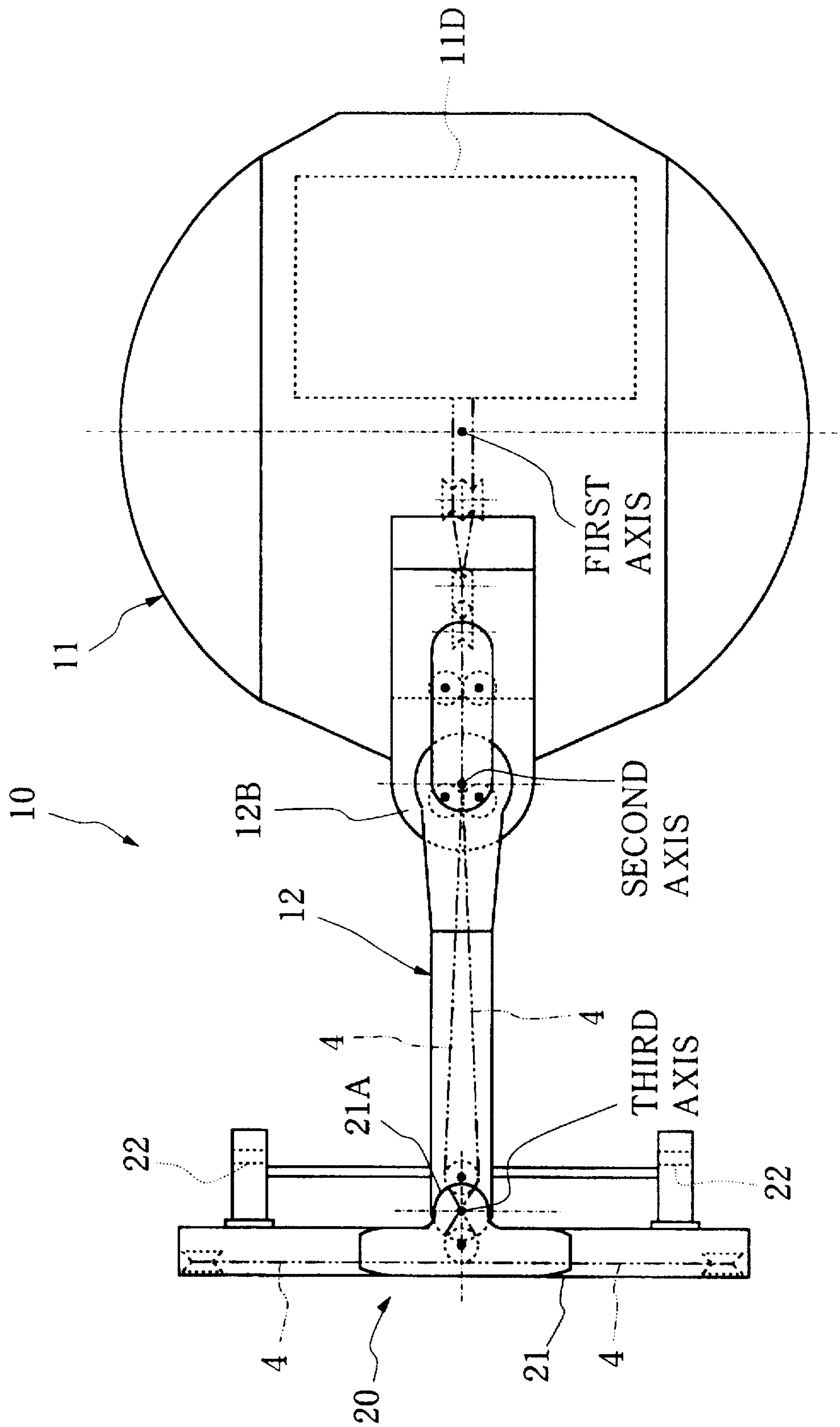

11D
FIRST AXIS
11
10
12B
SECOND AXIS
12
4
4
THIRD AXIS
21A
22
22
4
20
21
4

FIG. 2

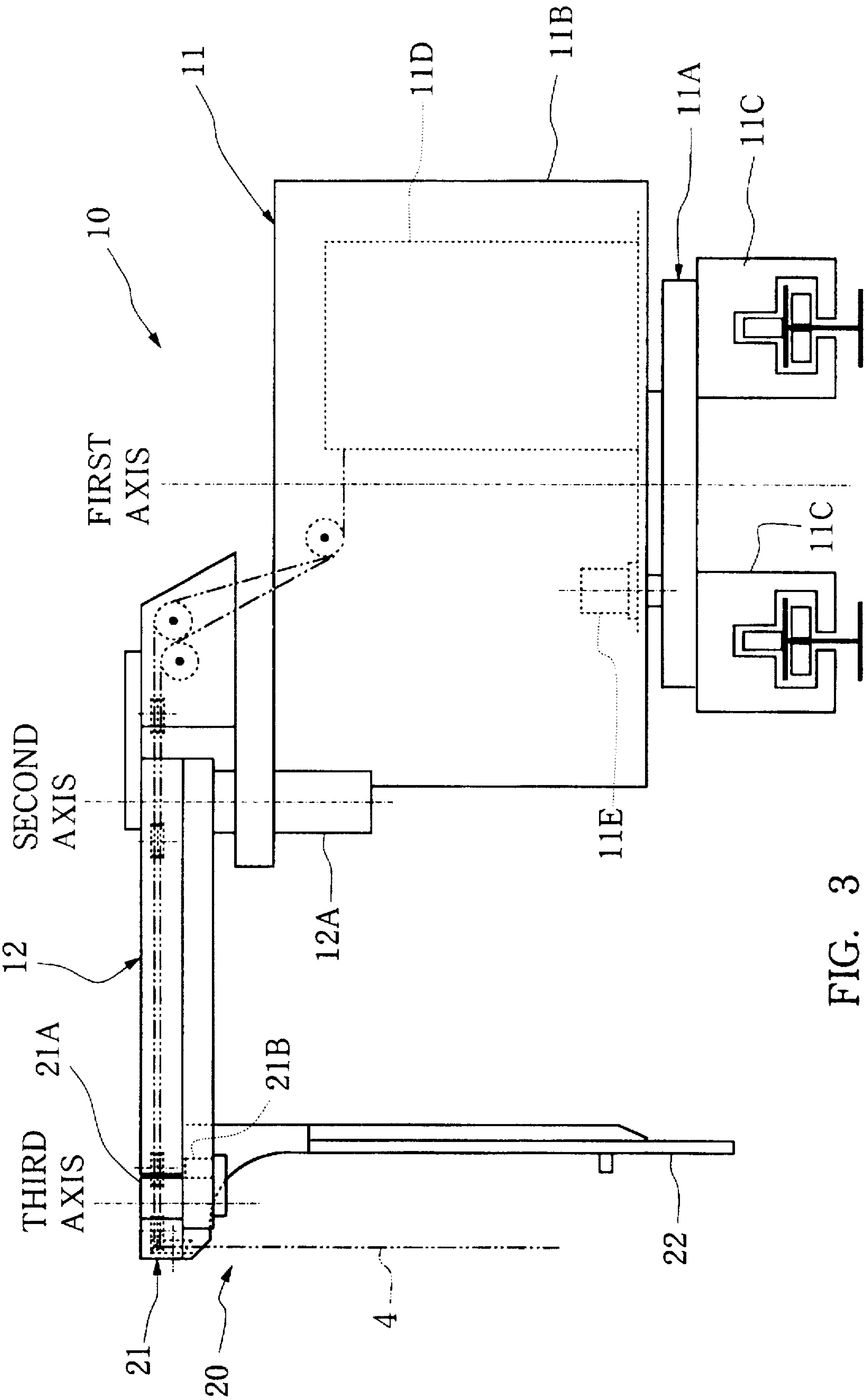

10
11
11D
11B
11A
11C
11C
FIRST AXIS
SECOND AXIS
THIRD AXIS
11E
12A
12
21A
21B
22
4
21
20

FIG. 3

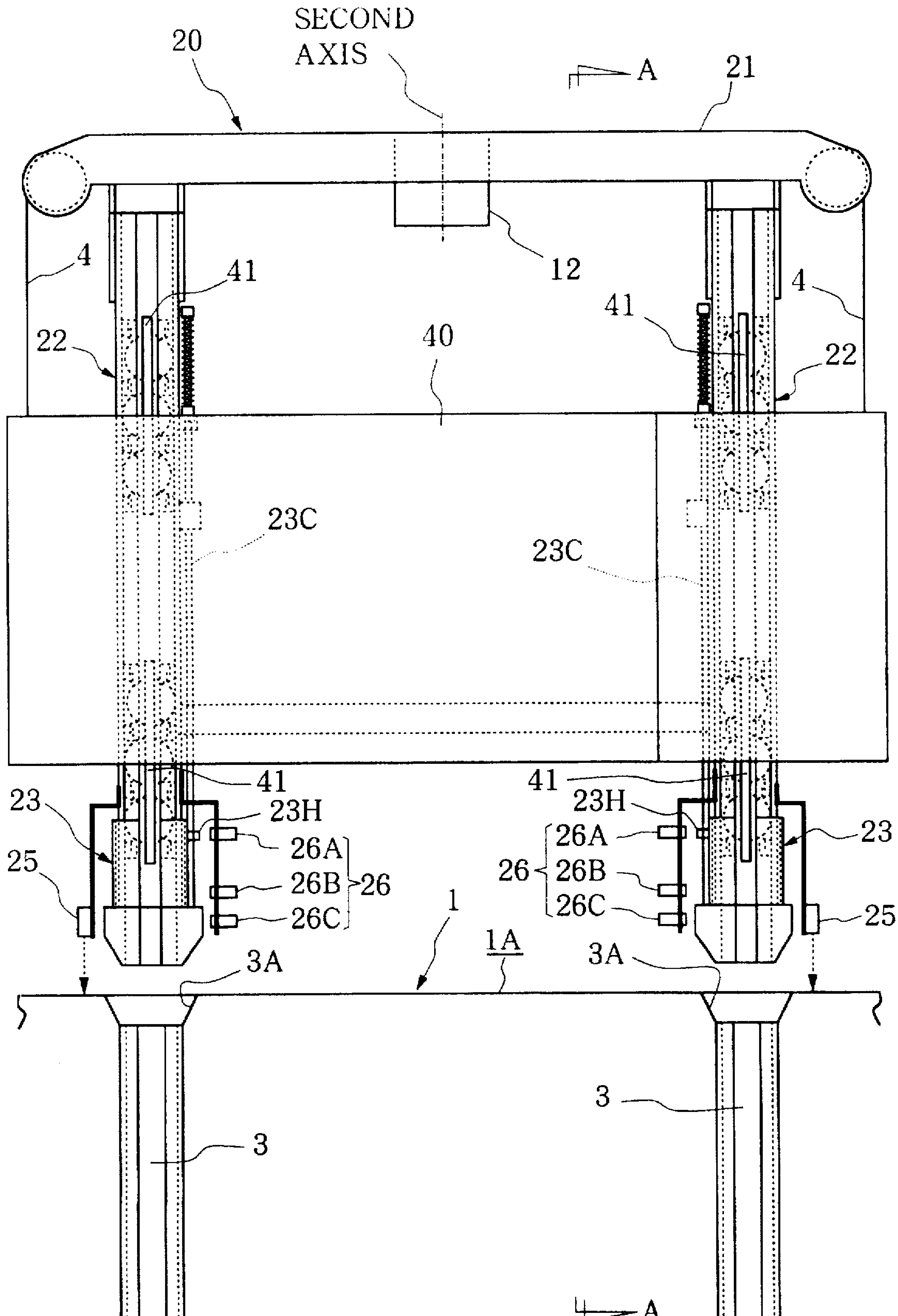

SECOND AXIS
20
A
21
12
4
41
40
22
23C
23H
23
25
26A
26B
26C
26
1
1A
3A
3
A

FIG. 4

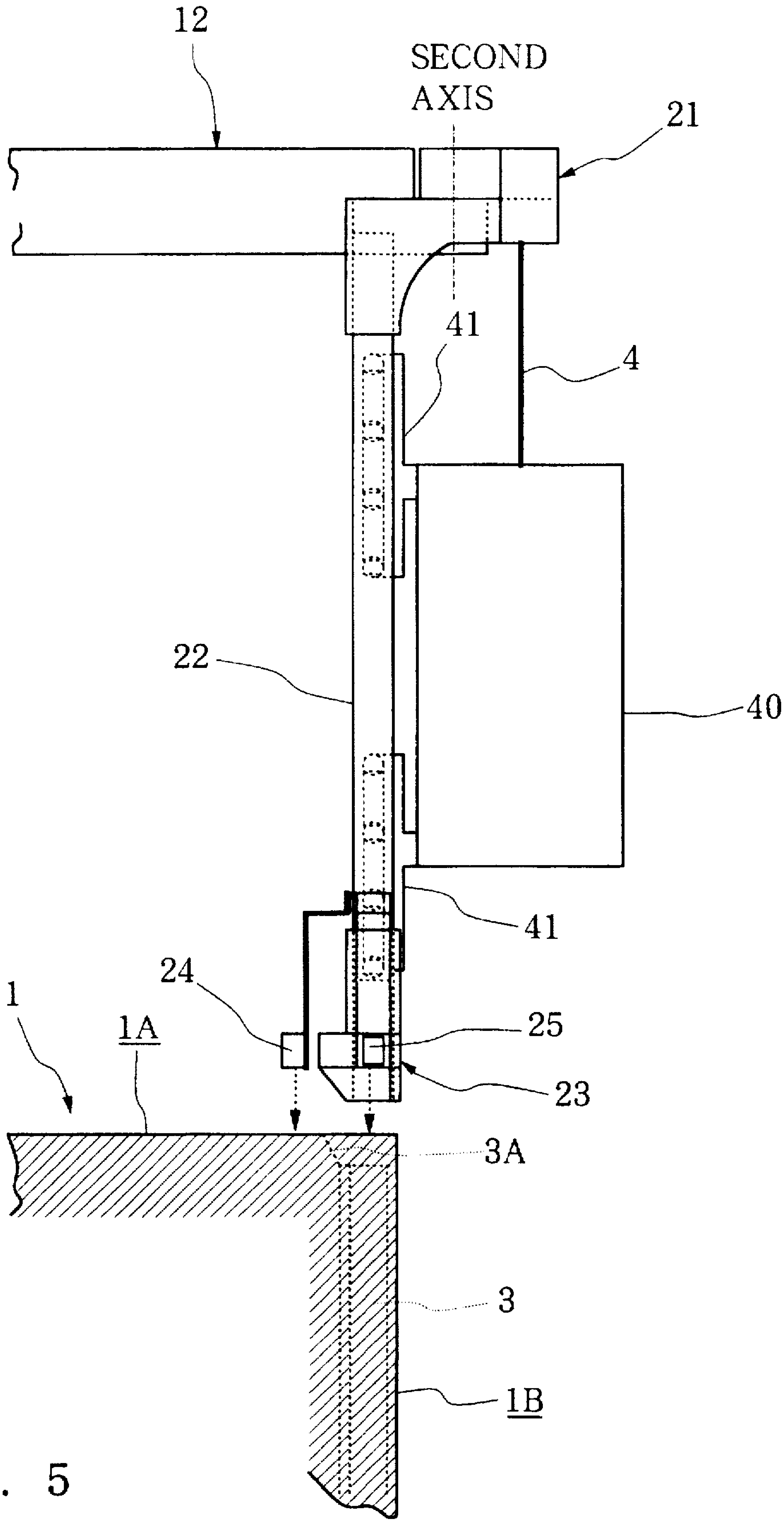


FIG. 5

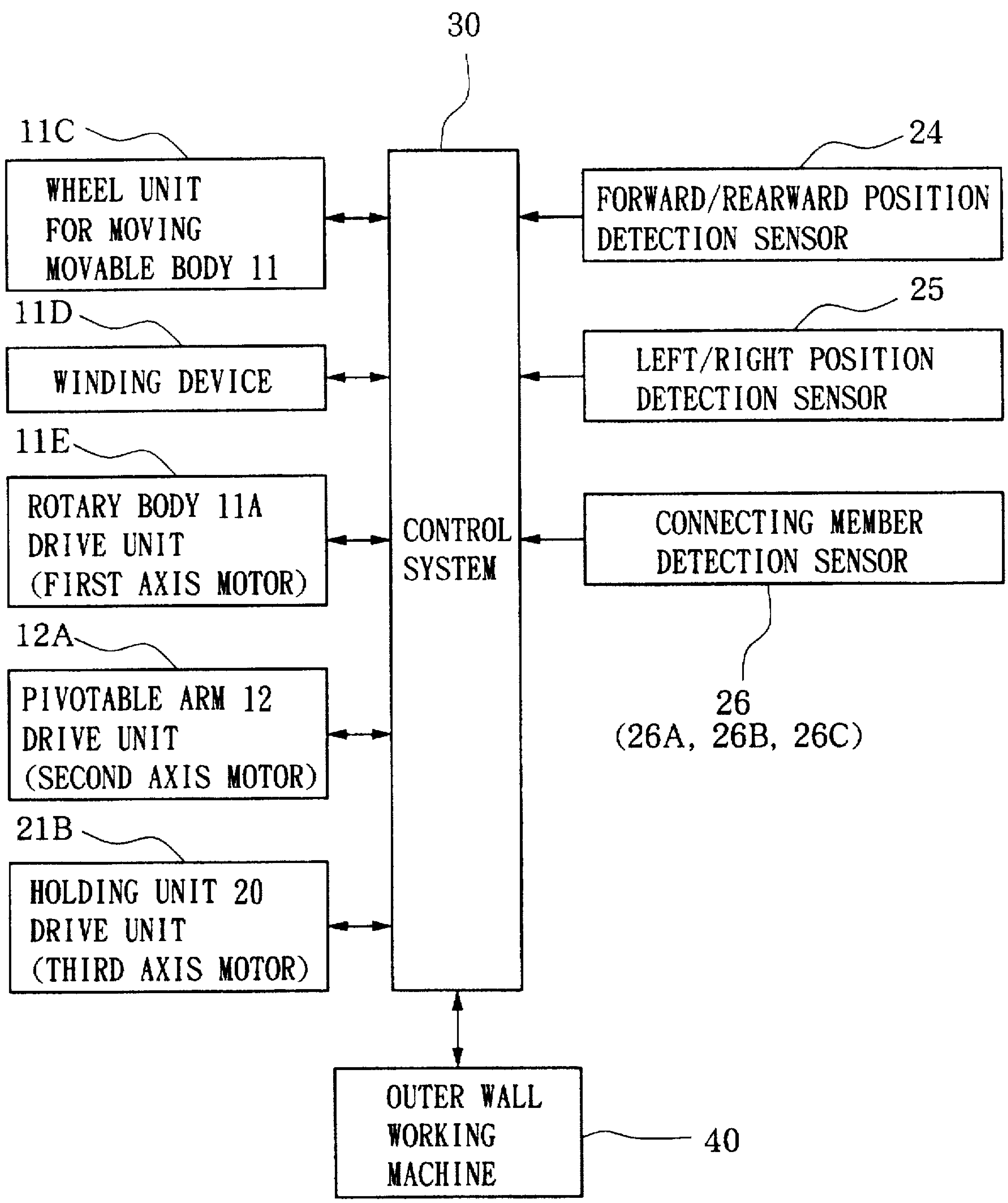

30
11C
WHEEL UNIT FOR MOVING MOVABLE BODY 11
11D
WINDING DEVICE
11E
ROTARY BODY 11A DRIVE UNIT (FIRST AXIS MOTOR)
12A
PIVOTABLE ARM 12 DRIVE UNIT (SECOND AXIS MOTOR)
21B
HOLDING UNIT 20 DRIVE UNIT (THIRD AXIS MOTOR)
CONTROL SYSTEM
24
FORWARD/REARWARD POSITION DETECTION SENSOR
25
LEFT/RIGHT POSITION DETECTION SENSOR
CONNECTING MEMBER DETECTION SENSOR
26 (26A, 26B, 26C)
OUTER WALL WORKING MACHINE
40

FIG. 6

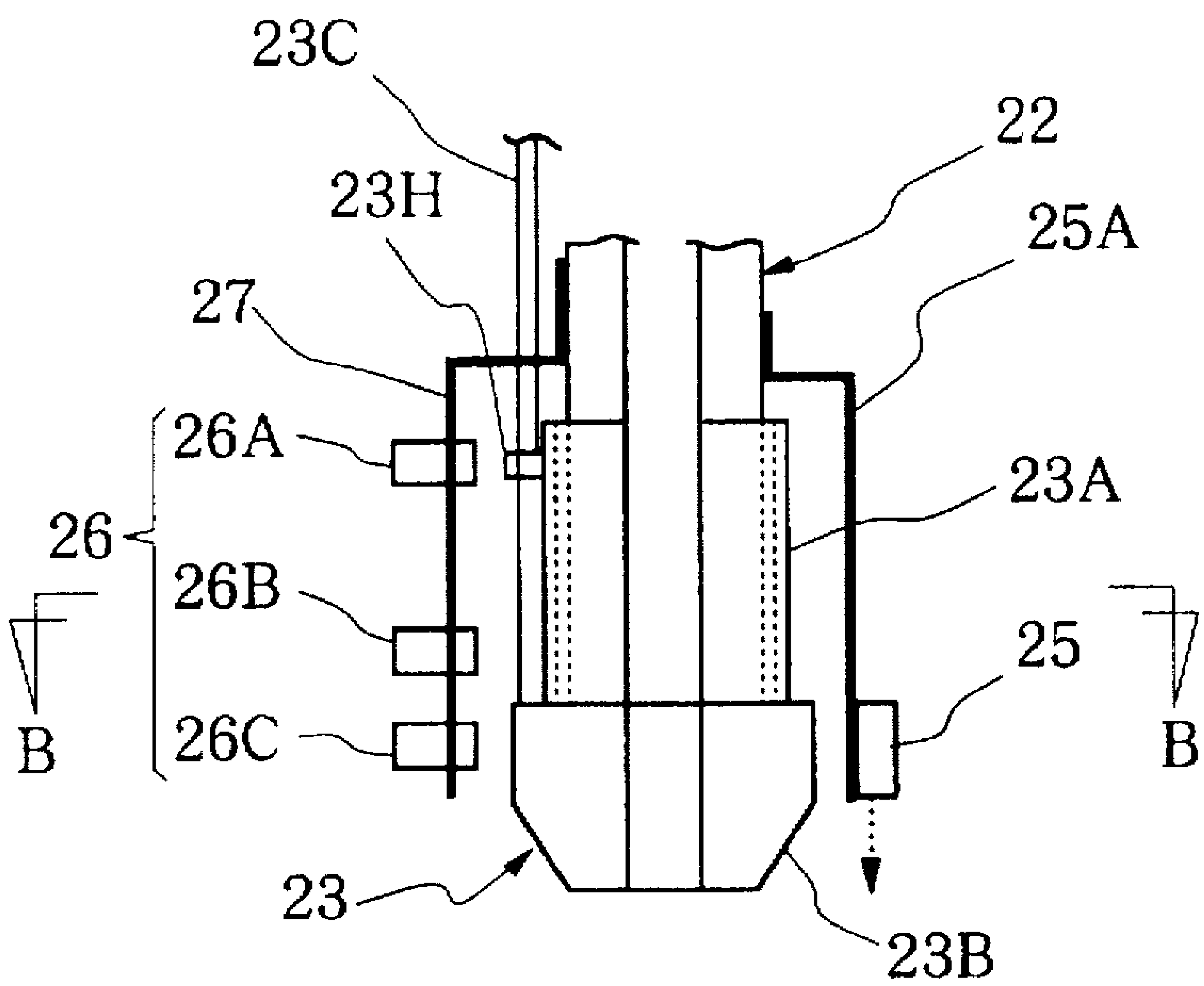


FIG. 7

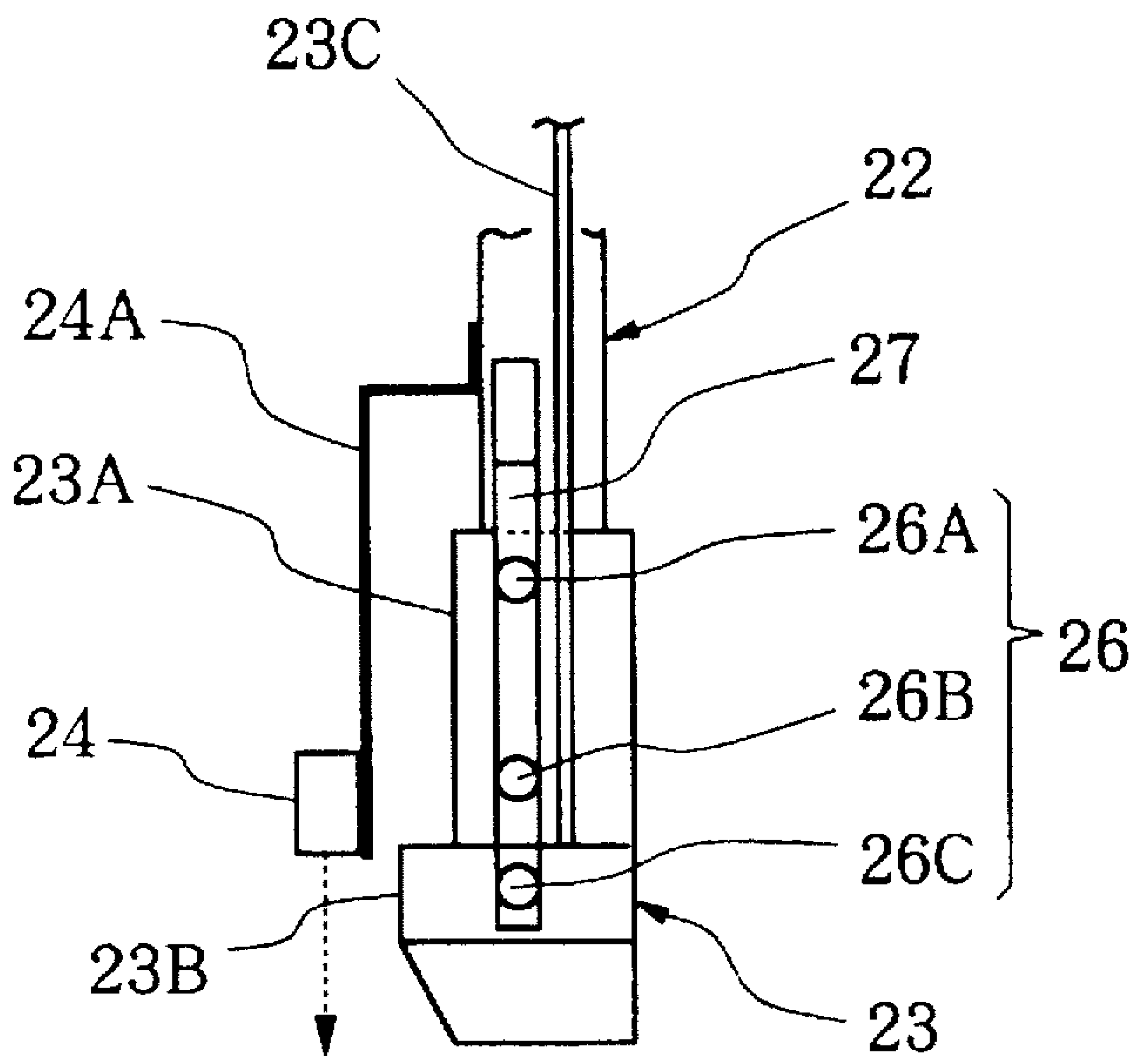


FIG. 8

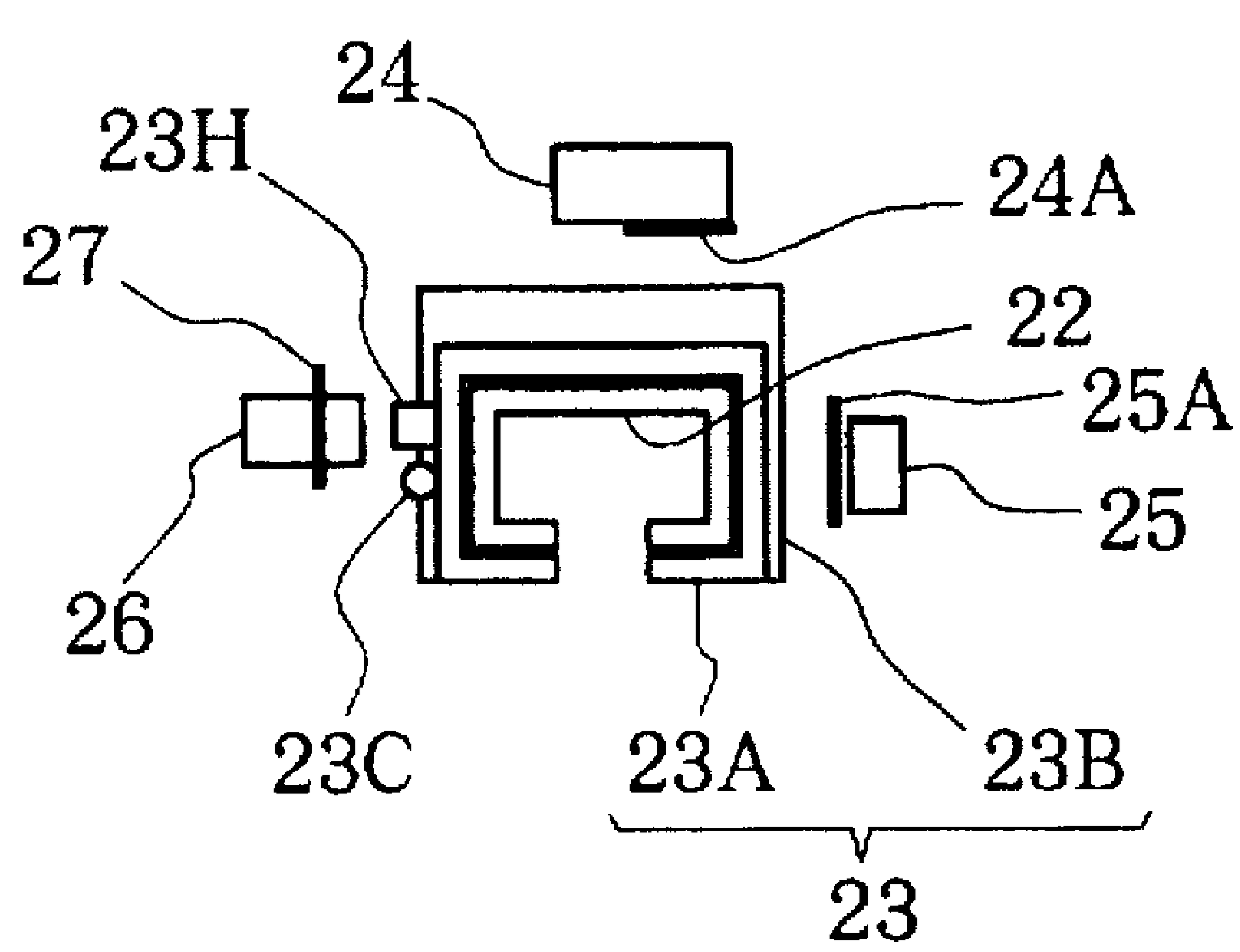


FIG. 9

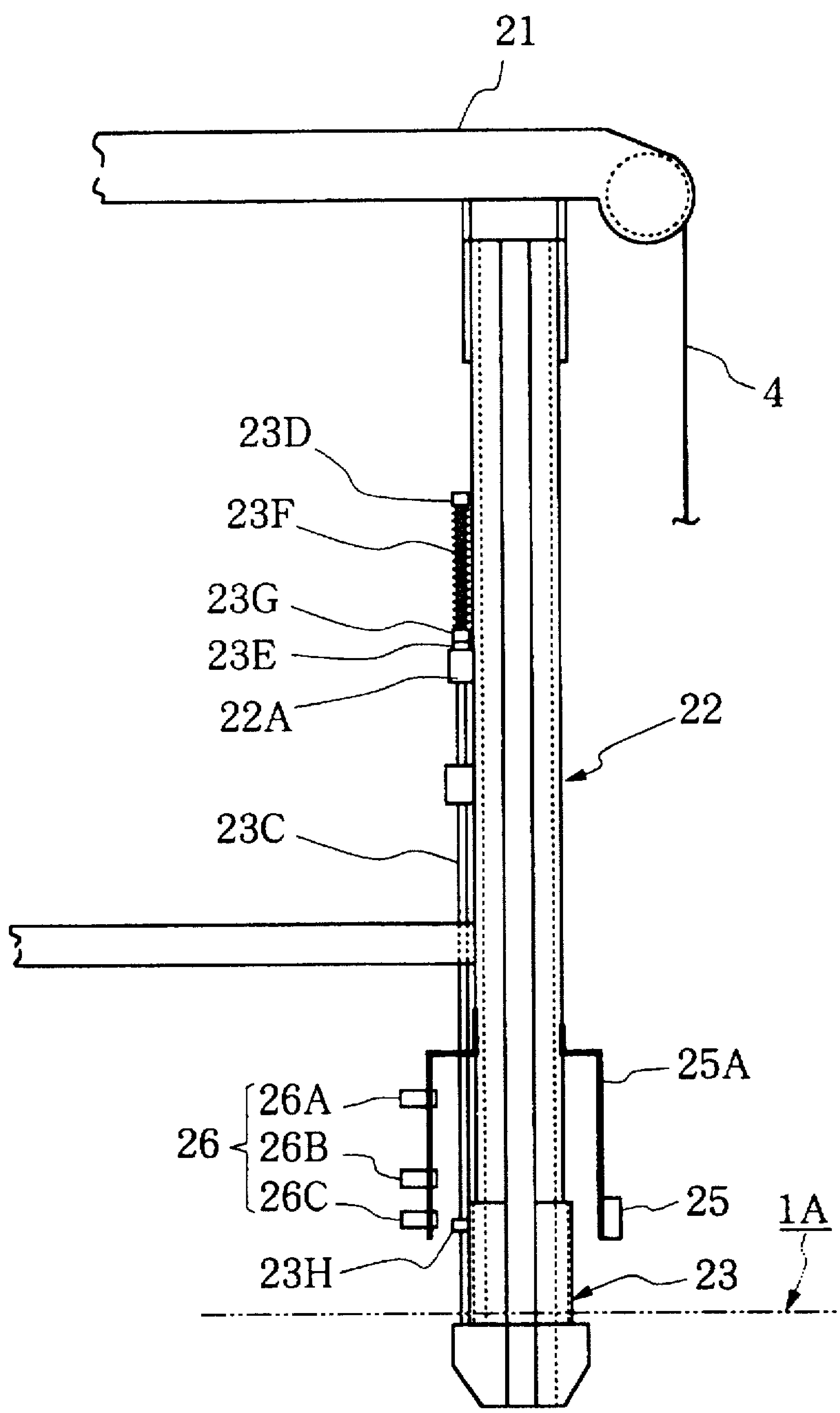


FIG. 10

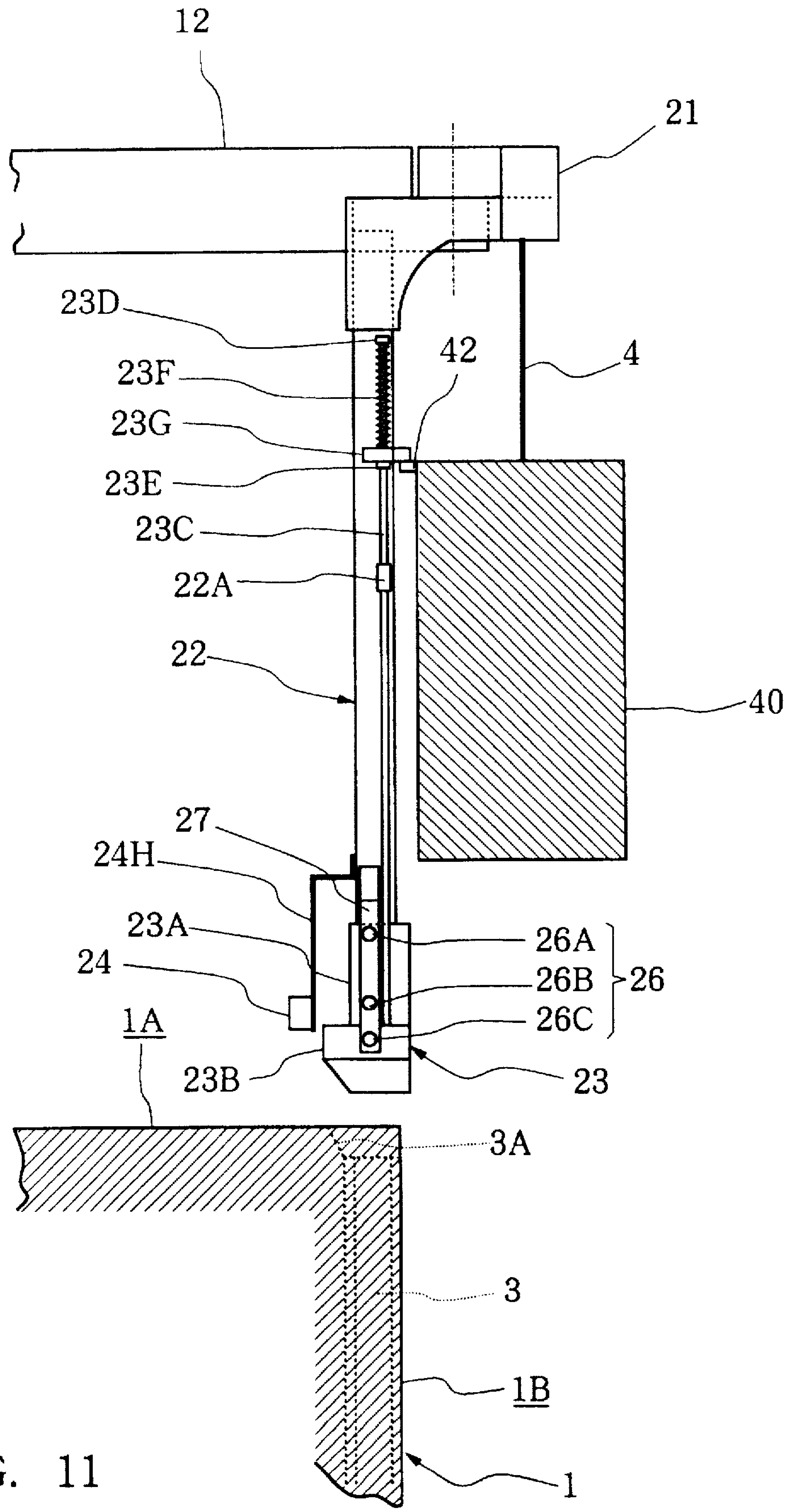

12
21
23D
42
4
23F
23G
23E
23C
22A
22
40
27
24H
23A
26A
26B
26C
26
24
1A
23B
23
3A
3
1B
1

FIG. 11

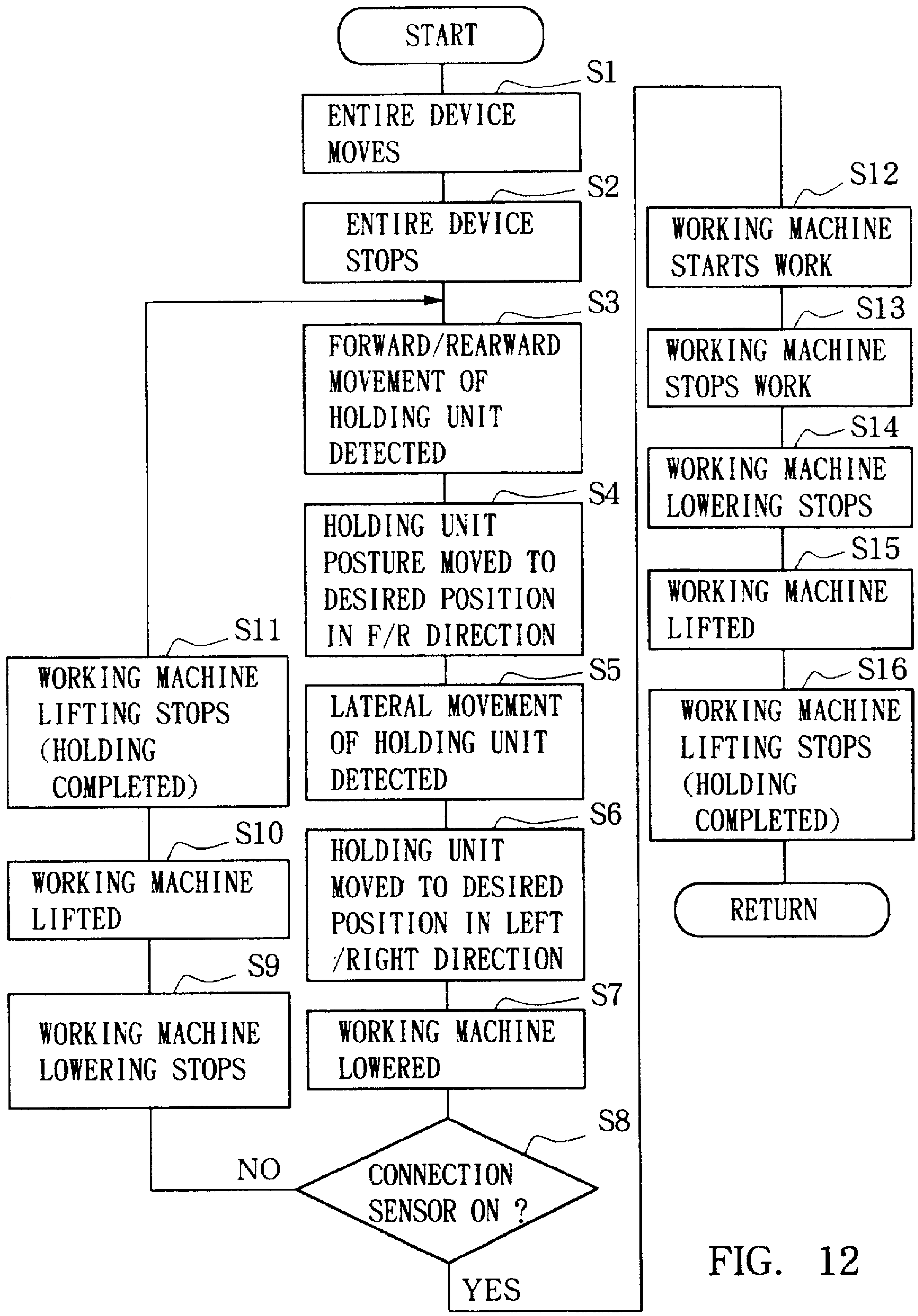

START
S1
ENTIRE DEVICE MOVES
S2
ENTIRE DEVICE STOPS
S3
FORWARD/REARWARD MOVEMENT OF HOLDING UNIT DETECTED
S4
HOLDING UNIT POSTURE MOVED TO DESIRED POSITION IN F/R DIRECTION
S5
LATERAL MOVEMENT OF HOLDING UNIT DETECTED
S6
HOLDING UNIT MOVED TO DESIRED POSITION IN LEFT /RIGHT DIRECTION
S7
WORKING MACHINE LOWERED
S8
CONNECTION SENSOR ON ?
NO
YES
S9
WORKING MACHINE LOWERING STOPS
S10
WORKING MACHINE LIFTED
S11
WORKING MACHINE LIFTING STOPS (HOLDING COMPLETED)
S12
WORKING MACHINE STARTS WORK
S13
WORKING MACHINE STOPS WORK
S14
WORKING MACHINE LOWERING STOPS
S15
WORKING MACHINE LIFTED
S16
WORKING MACHINE LIFTING STOPS (HOLDING COMPLETED)
RETURN

FIG. 12

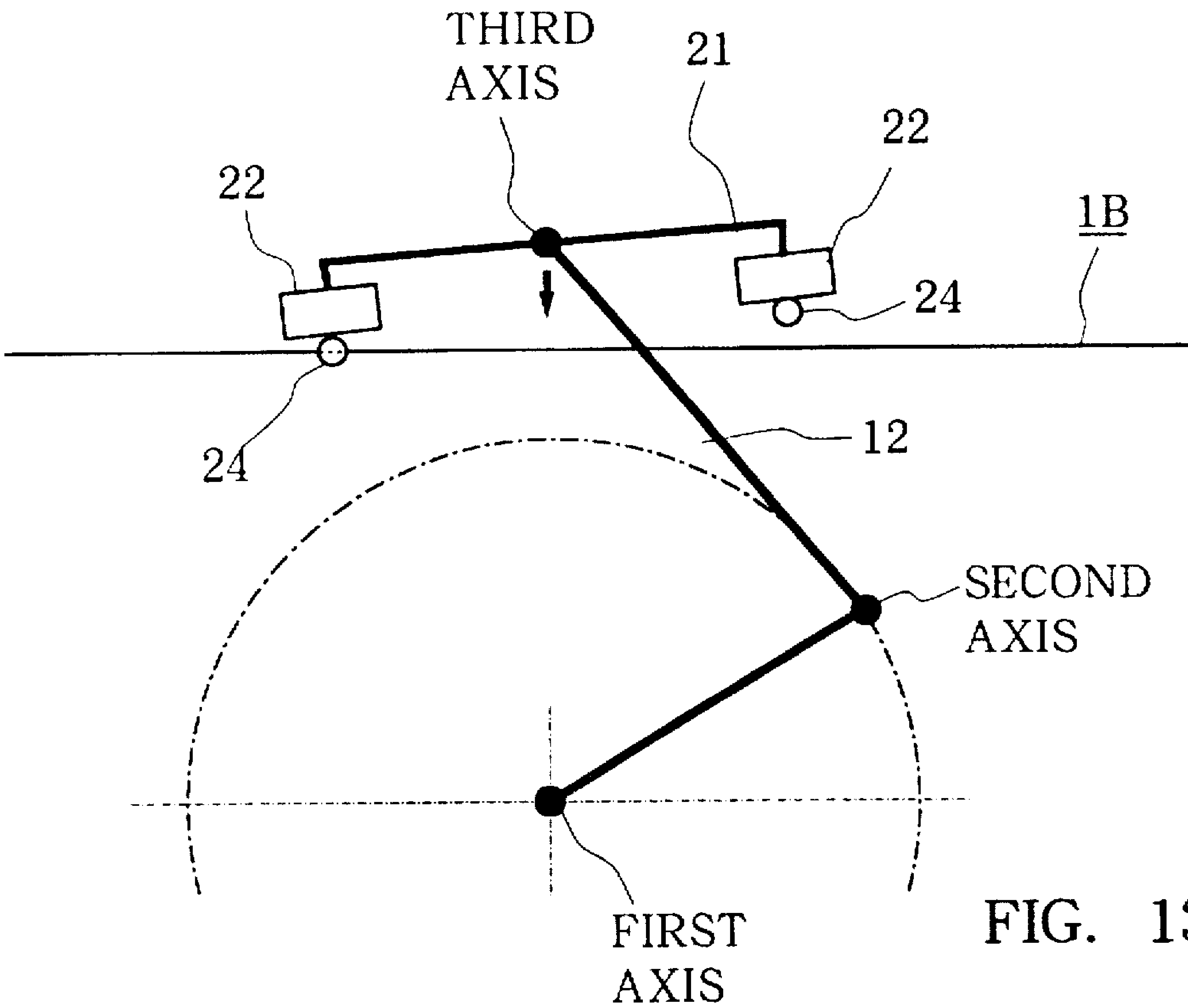


FIG. 13A

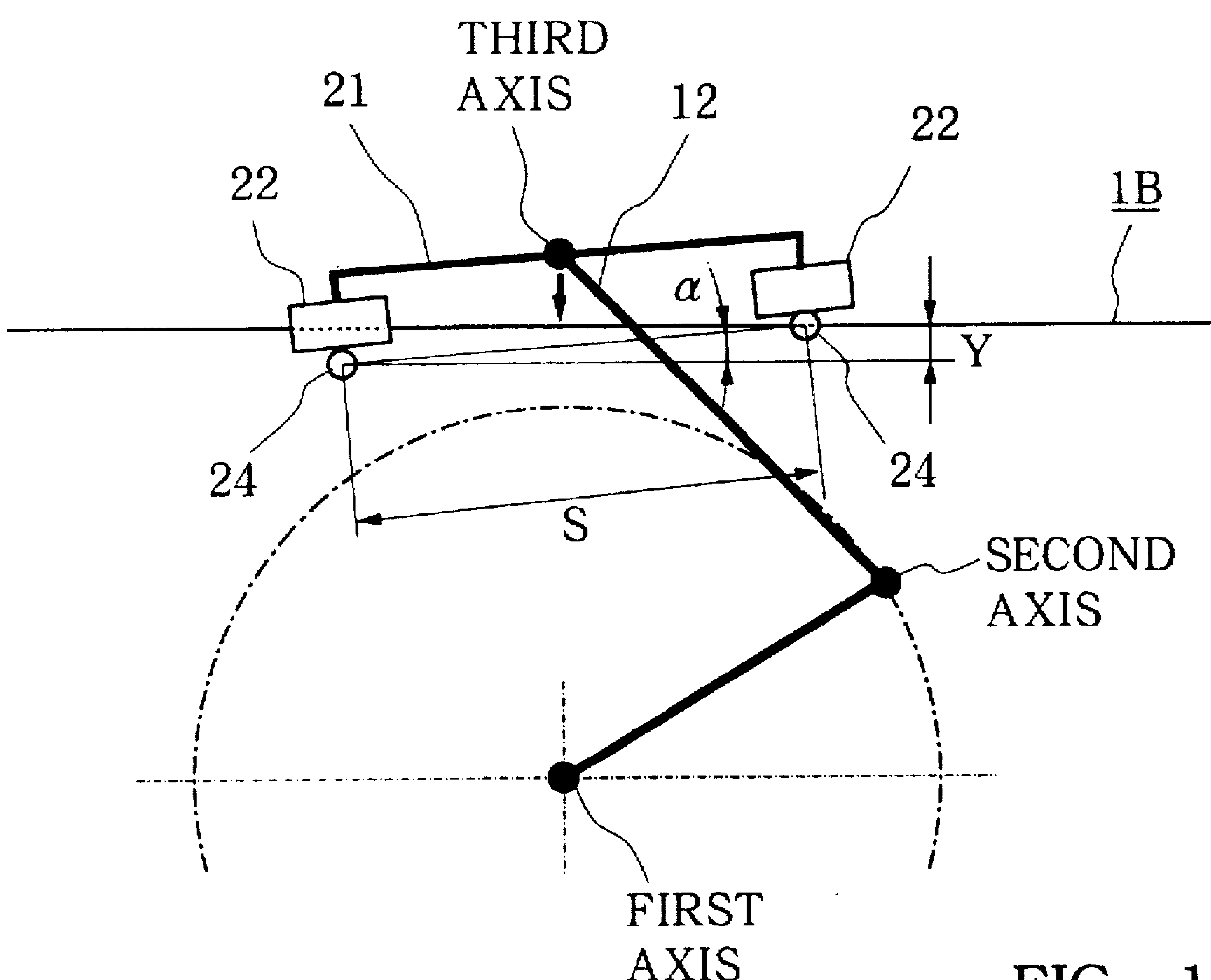


FIG. 13B

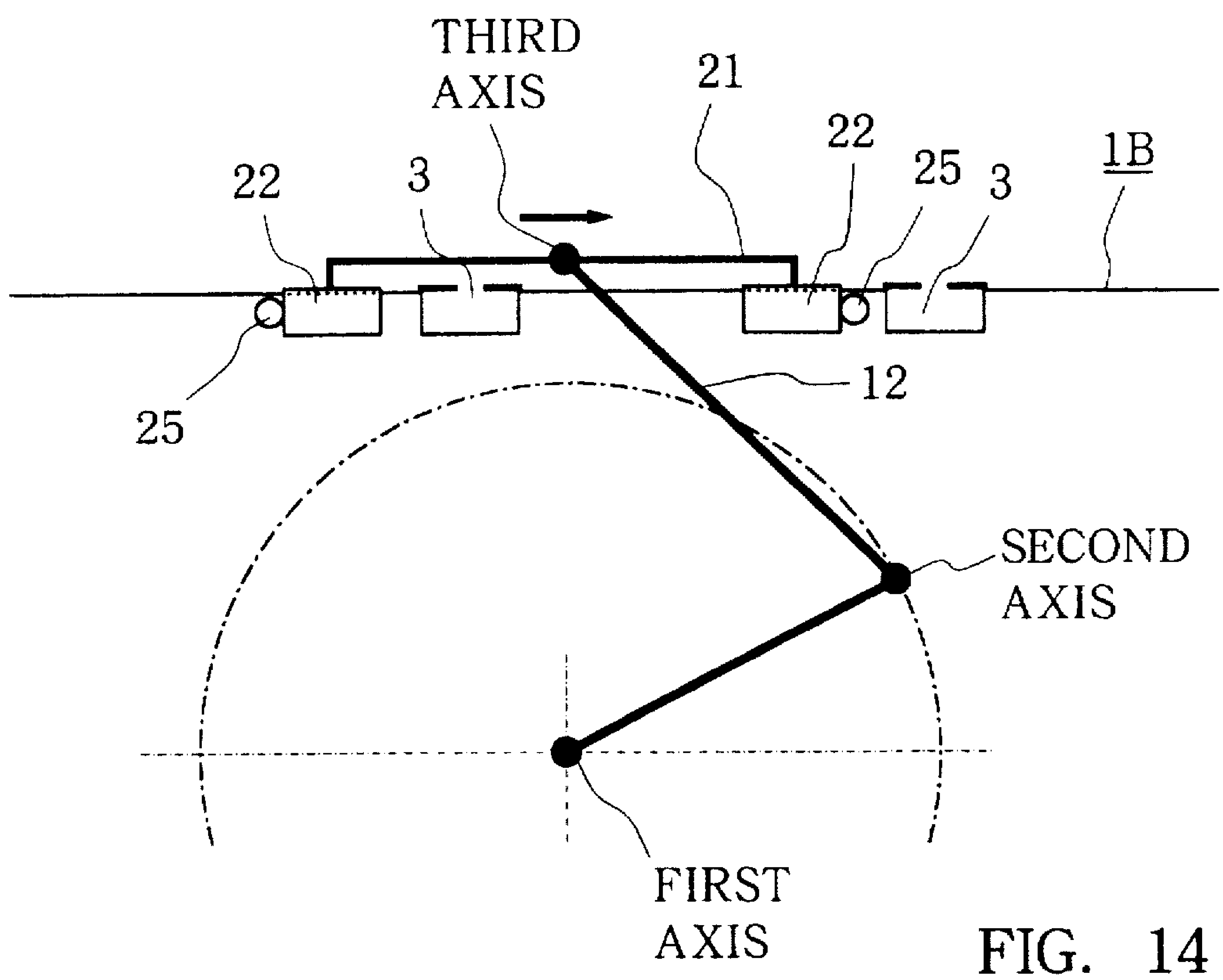

THIRD
AXIS
21
22
25
3
1B
22
3
25
12
SECOND
AXIS
FIRST
AXIS

FIG. 14

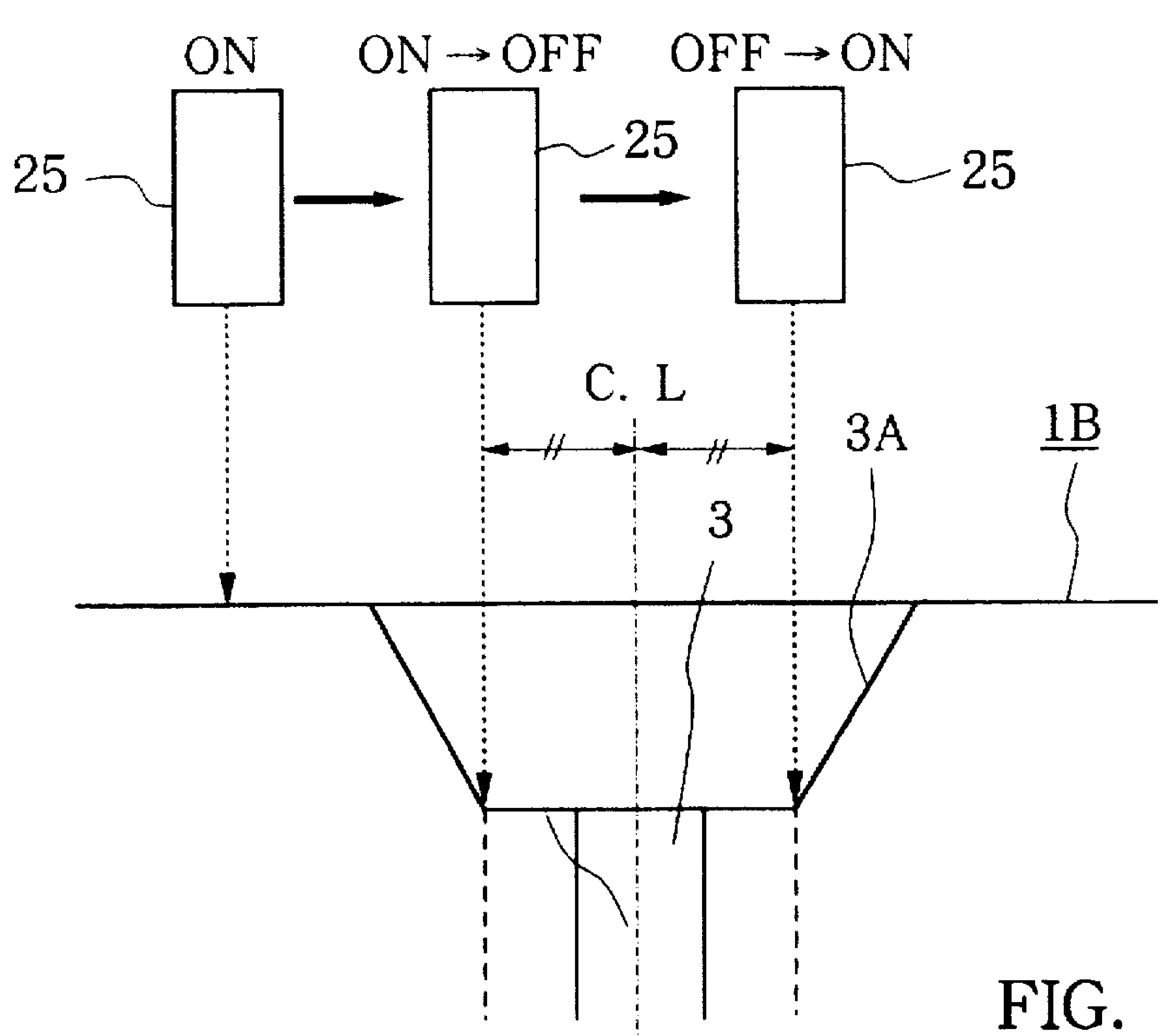

ON
ON → OFF
OFF → ON
25
25
25
C. L
3A
1B
3

FIG. 15

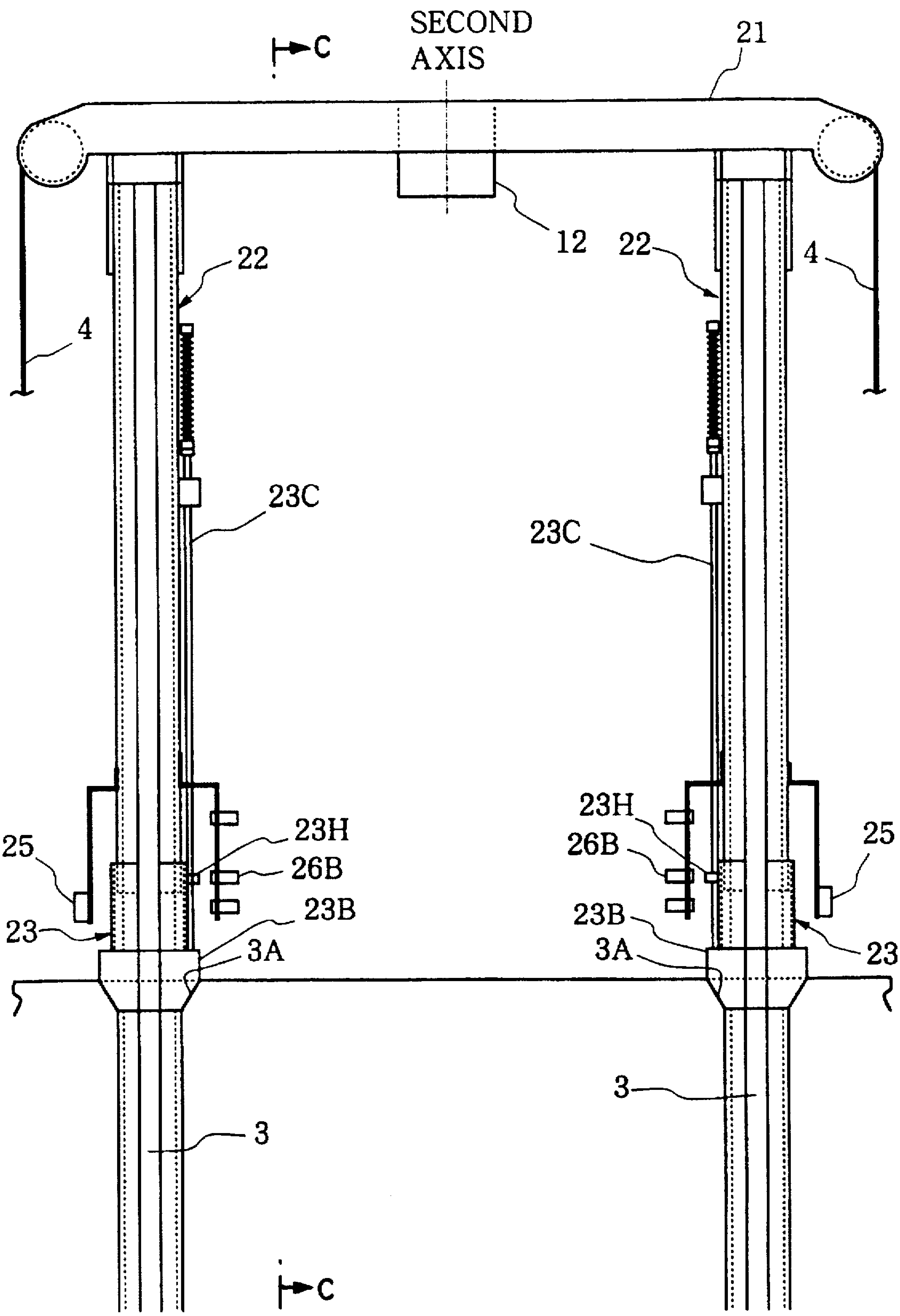

SECOND
AXIS
C
21
12
22
22
4
4
23C
23C
23H
26B
23B
3A
25
23
23H
26B
23B
3A
25
23
3
3
C

FIG. 16

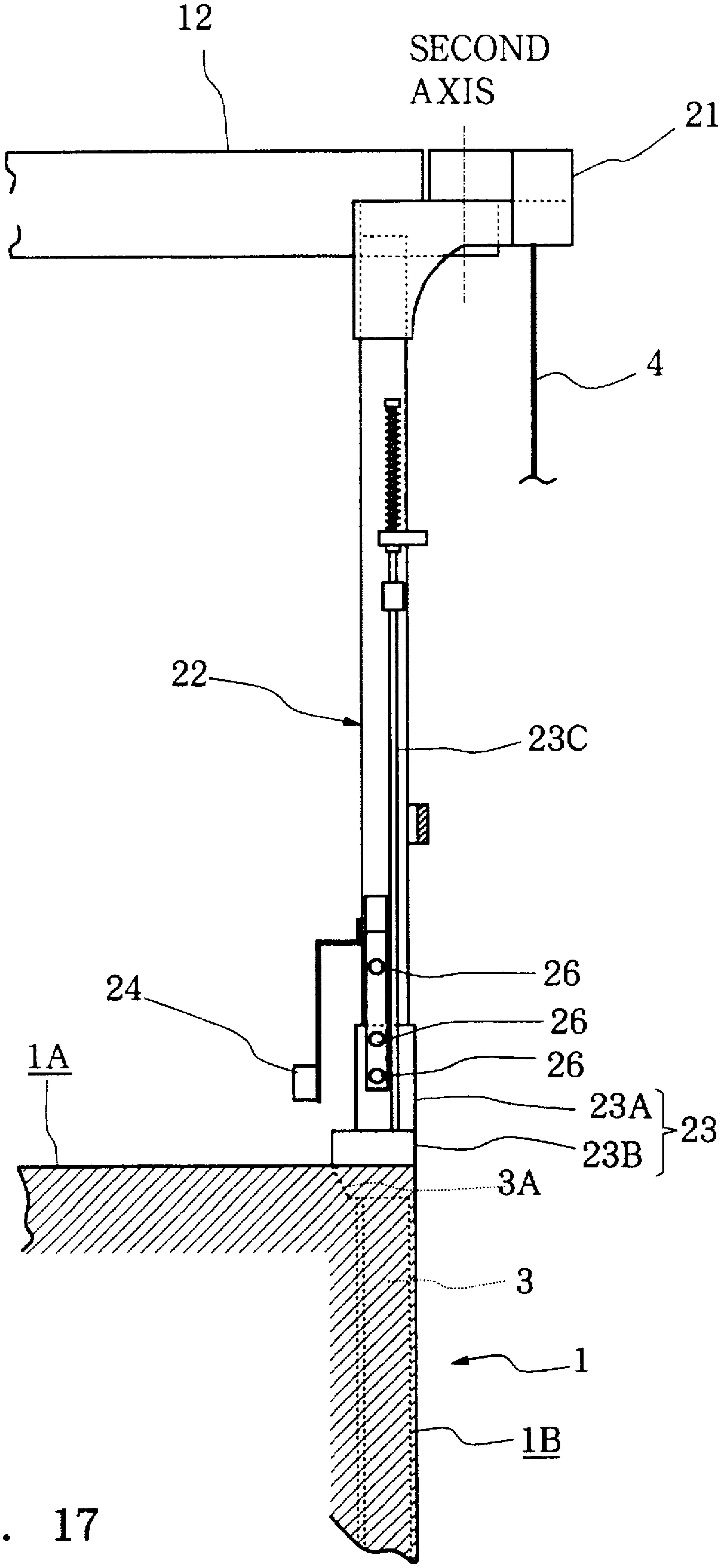


FIG. 17

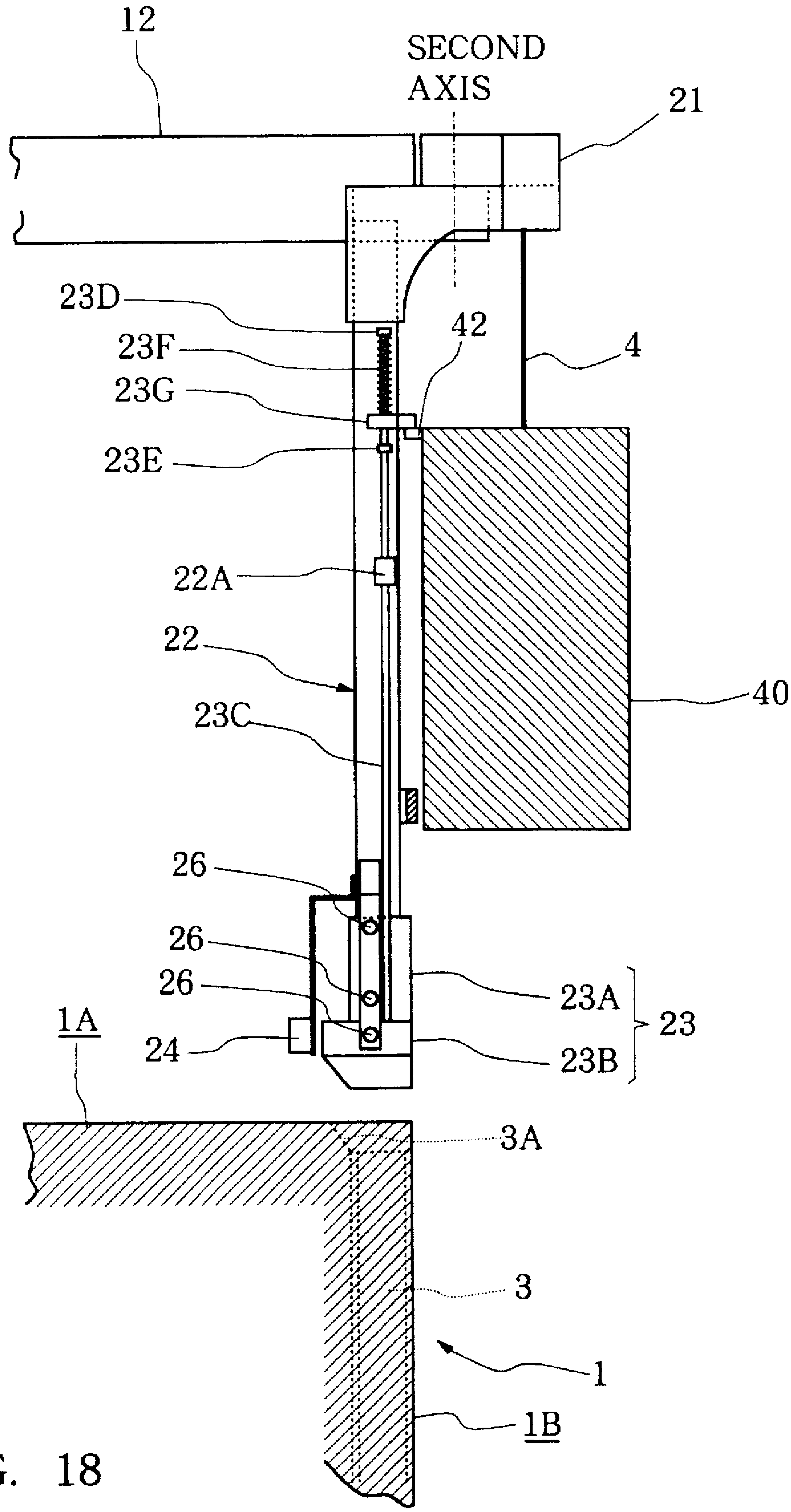

12
SECOND AXIS
21
23D
42
4
23F
23G
23E
22A
22
40
23C
26
26
26
23A
23
1A
24
23B
3A
3
1
1B

FIG. 18

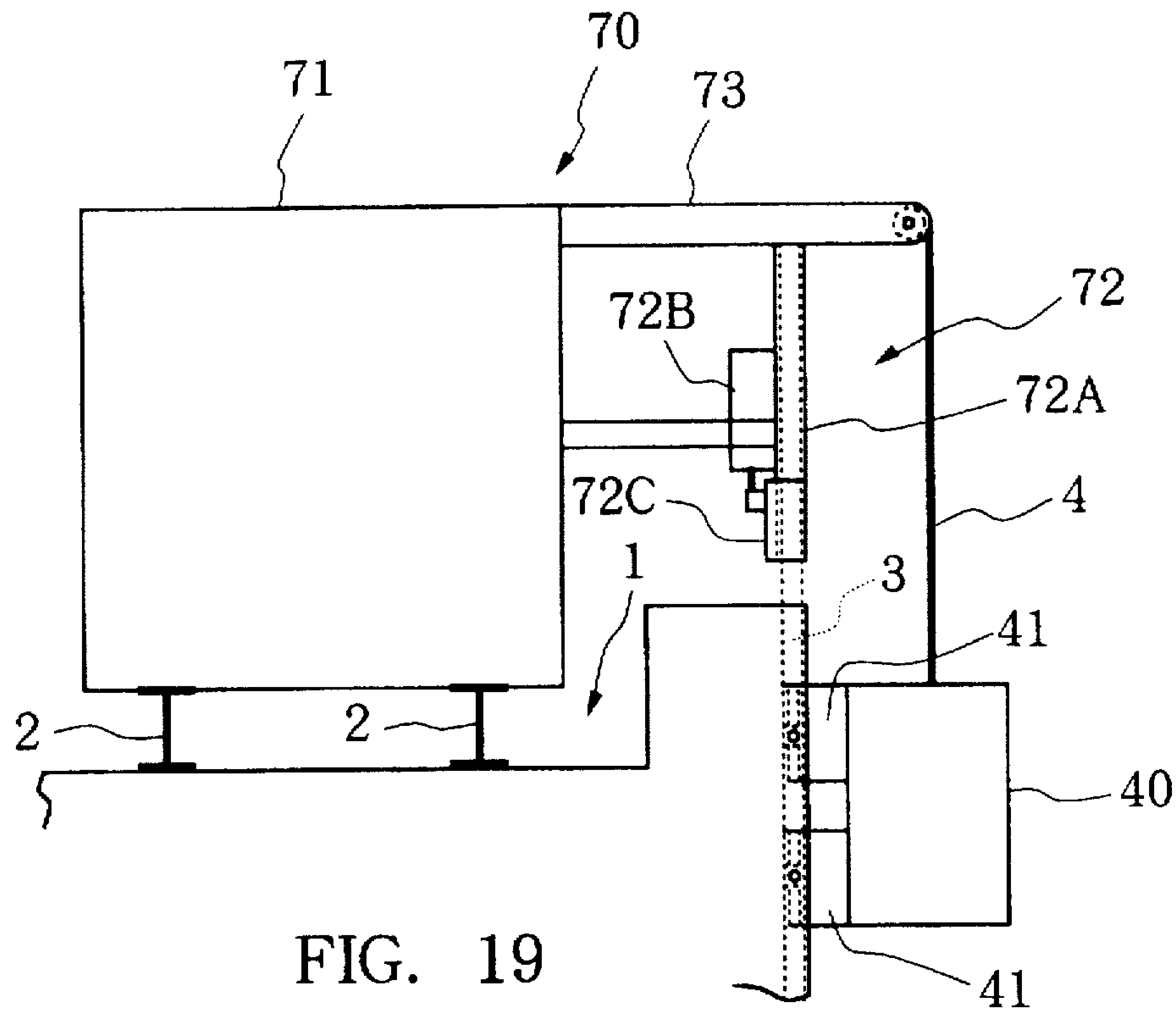


FIG. 19
PRIOR ART

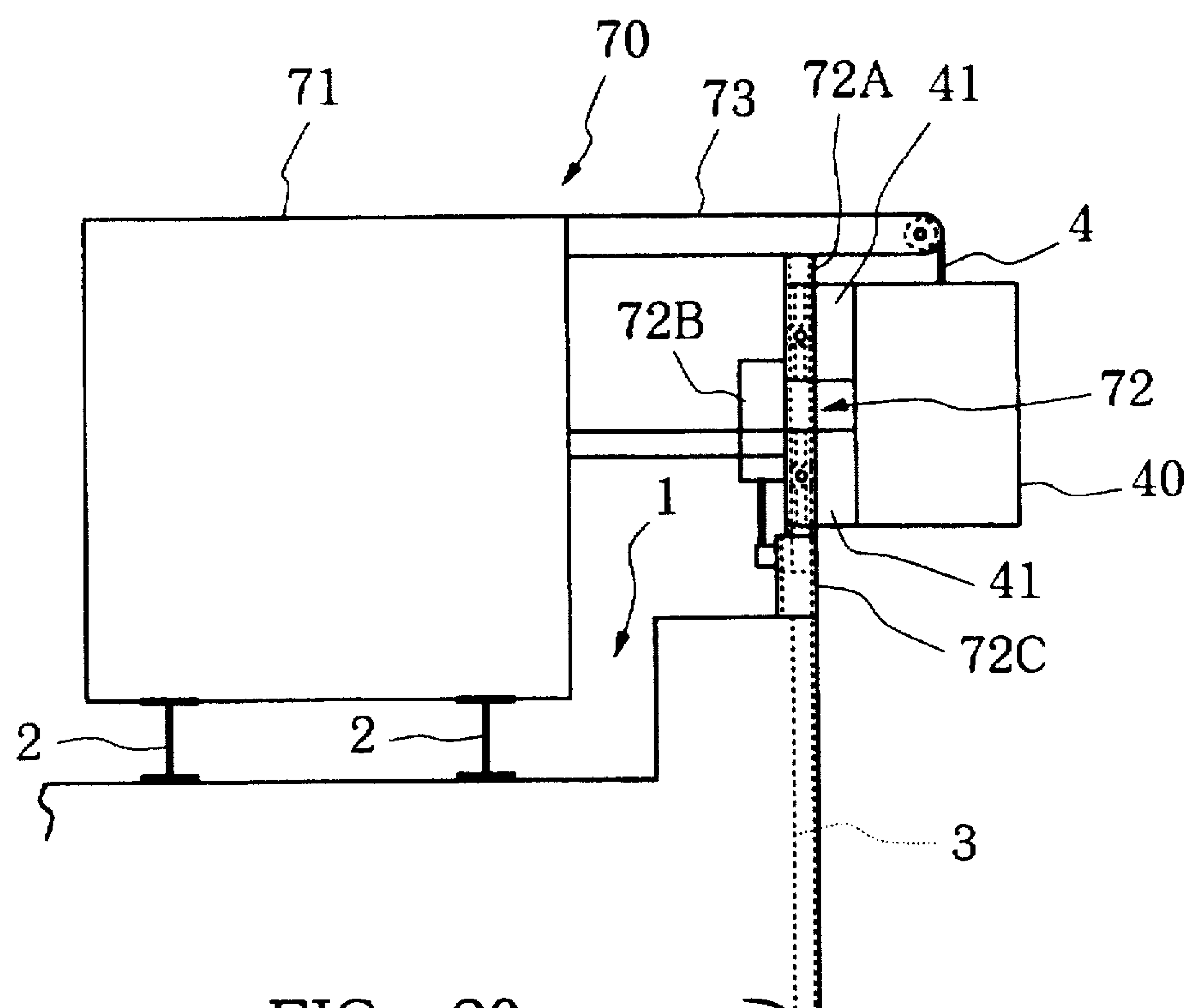


FIG. 20
PRIOR ART

SUSPENSION SUPPORT DEVICE FOR AN OUTER WALL WORKING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to a suspension support device for outer wall working machines such as an automatic work unit and a manned cage working on an outer wall of a building capable of suspending an outer Wall working machine from a roof of a building by means of ropes and lifting and lowering the outer wall working machine along guide grooves formed on the outer wall by taking up and feeding out the ropes.

In performing work such as new building work, repair and cleaning on an outer wall surface of a building, it is known to lift and lower an automatic machine or a manned cage suspended from the roof by means of ropes along the outer wall surface and perform the work by the automatic machine or a workman in the cage.

As the height of a building increases, an outer wall working machine tends to be influenced by wind with resulting sway in lifting or lowering of the working machine. Moreover, the working machine tends to move away from the outer wall surface due to reaction from the wall surface. For preventing this, there is provided a device according to which guide grooves made in the form of channel steel are formed in the moving direction of the working machine, i.e., in a vertical direction, on the outer wall surface of the building and fitting and moving members (i.e., rollers) which are fittedly engaged in these guide grooves are mounted on the working machine. By causing these fitting and moving members to move in the guide grooves, the working machine is guided along the guide grooves and also is prevented from moving away from the outer wall surface.

The fitting and moving members are normally provided on both sides of the outer wall working machine whereas the guide grooves are formed with an interval which is equal to the interval between the two fitting and moving members. By this arrangement, the outer wall working machine performs work while it moves down with the fitting and moving members fitted in the guide grooves on both sides of the working machine. After completion of the work, the working machine is lifted until the fitting and moving members come out of engagement with the guide grooves and then the working machine is moved to a next work area. Then, the fitting and moving members of the working machine are fittedly engaged in the guide grooves of the new work area and a next work is started.

In the schematic side elevation of FIG. 19, a support device **70** is provided movably along rails **2** laid along an outer wall on the roof of a building **1**. In a main body **71** of the device **70** is provided a winder (not shown) for taking up and feeding out ropes **4** for suspending an outer wall working machine **40**. A holding unit **72** is also provided in the main body **71** through an arm **73** for holding the working machine **40**.

The holding unit **72** includes a pair of holding guide members **72A** provided with an interval equal to the interval between a pair of guide grooves **3** formed on the building **1** (i.e., the interval between the fitting and moving members **41** of the working machine **40**). By lifting the working machine **40** up to the location of the holding unit **72** and causing the fitting and moving members **41** to engage fittedly in the holding guide members **72A**, the working machine **40** is held stably by the holding unit **72**.

The holding guide members **72A** have the same cross section as the guide grooves **3** of the building **1** and are long enough to receive the fitting and moving members **41**. The lower end portions of the holding guide members **72A** are formed so as to have a predetermined interval between the upper surface of the building **1** and are provided with connecting members **72C** which are driven by drive means **72B** such as a motor cylinder to project from and withdraw into the holding guide members **72A**.

In the projecting state, the connecting members **72C** connect the holding guide members **72A** with the guide grooves **3** of the building **1** and thereby guide the fitting and moving members **41** to move smoothly between the guide grooves **3** and the holding guide members **72A**.

The ropes **4** suspending the outer wall working machine **40** extend from the winder in the main body **71** to the holding unit **72** via the arm **73** and are suspended from the upper portion of the holding unit **72**.

According to this support device **70**, the outer wall working machine **40** is lowered and lifted by feeding out and taking up of the ropes **4** by the winder and, as shown in FIG. **20**, the working machine **40** is held by the holding unit **72** by causing the fitting and moving members **41** of the working machine **40** to engage in the holding guide members **72A** whereby an area in which the working machine is lowered and lifted (i.e., a working area of the working machine **40**) can be changed with the working machine held by the holding unit **72**.

More specifically, the working machine **40** is lifted from the state in which the fitting and moving members **41** are fittedly engaged in the guide grooves **3** to the state in which the fitting and moving members **41** are engaged in the holding guide members **72A** of the holding unit **72** (at this time, the connecting members **72C** are in the projecting state and connect the holding guide members **72A** with the guide grooves **3**). Then, the connecting members **72C** are withdrawn and the support device **70** is moved along the rails **2** to a position where the holding guide members **72A** of the holding unit **72** oppose desired guide grooves **3** while holding the working machine **40** in the holding unit **72**. The connecting members **72C** are now driven to project to connect the holding guide members **72A** with the guide grooves **3** and the working machine **40** is lowered to shift the fitting and moving members **41** from the holding guide members **72A** to the guide grooves **3** whereby the working machine **40** can be lowered along the guide grooves **3**.

In the above described prior art support device **70**, positioning for aligning the holding guide members **72A** of the holding unit **72** with the guide grooves **3** is made by stopping the support device **70** at a predetermined position on the rails **2**. More specifically, a sensor is provided either on the rails **2** or the support device **70** and a member to be detected by the sensor is provided on the other. The holding guide members **72A** of the holding unit **72** are intended to align with the guide grooves **3** by stopping the support device **70** at a position where the sensor has detected the member to be detected. It has, however, been found difficult to align, with a high accuracy, the holding guide members **72A** with the guide grooves **3** with such a positioning method and, as a result, there often occurs a case where the working machine **40** held by the holding guide members **72A** cannot be shifted to the guide grooves **3** or, conversely, a case where the working machine **40** cannot be received from the guide grooves **3** to the holding guide members **72A**.

Further, there is a case where structure of a building prevents rails from being laid along the outer wall surface of the building. In such building, positioning of the holding guide members **72A** to the guide grooves **3** becomes further difficult.

Furthermore, the structure for projecting and withdrawing the connecting members 72C which connect the holding guide members 72A with the guide grooves 3 by the drive means 72B is complicated and costly.

It is, therefore, an object of the invention to provide a suspension support device for an outer wall working machine capable of performing positioning of the holding guide members of the holding unit to the guide grooves with a high accuracy and also having simplified and inexpensive connecting members which connect the holding guide members with the guide grooves.

SUMMARY OF THE INVENTION

For achieving the above described object of the invention, there is provided a suspension support device provided movably on the upper surface of a building for suspending, by means of ropes, an outer wall working machine having fitting and moving members which can be fittedly engaged in a pair of guide grooves formed vertically on an outer wall surface of the building, and lowering and lifting the outer wall working machine along the guide grooves comprising a main body, an arm structure connected to the main body, a holding unit connected to the arm structure in a manner to be movable forwardly and rearwardly, laterally and pivotable about a vertical axis and including a pair of holding guide members provided at an interval equal to an interval of the pair of guide grooves and being capable of receiving the fitting and moving members, arm structure drive means for driving the arm structure to move the holding unit, sensor means provided at both sides of the holding unit at positions corresponding to the holding guide members for detecting the upper edge of the building, and drive control means for controlling driving of the arm structure drive means in response to detection information supplied by the sensor means, said drive control means controlling driving of the arm structure to move the holding unit in a direction perpendicular to the outer wall surface while maintaining the posture of the holding unit, calculate angle and position of the holding unit with respect to the outer wall surface in response to the detection information concerning the outer wall surface supplied by the sensor means, move the holding unit to a position which is parallel to the outer wall surface and coincidental with the guide grooves in a direction perpendicular to the outer wall surface and thereafter move the holding unit in a direction parallel to the outer wall surface in a horizontal plane while maintaining the posture of the holding unit and, responsive to the detection information concerning the guide grooves supplied by the sensor means, bring the holding unit to a position at which the holding guide members align with the guide grooves.

According to the invention, the holding guide members of the holding unit can be positioned, with a high accuracy, to the guide grooves formed on the outer surface of the building whereby the outer wall working machine held by the holding unit can be shifted smoothly to the guide grooves and, conversely, the outer wall working machine located on the guide grooves can be shifted smoothly to the holding unit.

In one aspect of the invention, the lower ends of the holding guide members of the holding unit are spaced from the upper edge of the building by a predetermined distance and said holding unit further comprises connecting members provided vertically slidably in the lower portion of the holding guide members to project from and withdraw into the holding guide members and thereby connect and disconnect the holding guide members with the guide grooves of the building and said holding unit further comprises actuator means connected to the connecting members, said connecting members being withdrawn into the holding guide members by operation of the actuator means by the outer wall working machine when the outer wall working machine is lifted and held by the holding guide members and said connector members projecting from the holding guide members when the outer wall working machine is lowered from the holding guide members to the outer wall surface of the building and thereby connecting the holding guide members with the guide grooves.

According to this aspect of the invention, since the connecting members connecting the holding guide members with the guide grooves are operated by the outer wall working machine in such a manner that, when the outer wall working machine is lifted and held by the holding unit, the connecting members are withdrawn and received in the holding guide members and, when the outer wall working machine is lowered from the holding unit to the building side, the connecting members project and connect the holding guide members with the guide grooves as the outer wall working machine is lowered, the structure of the connecting members can be simplified and manufacturing cost thereby can be reduced.

In another aspect of the invention, said holding unit further comprises a spring provided between the connecting members and the actuator means for permitting, by elastic deformation of the spring, vertical movement of the outer wall working machine in a state where the connecting members are withdrawn and received in the the holding guide members.

According to this aspect of the invention, vertical movement of the outer wall working machine can be permitted when the outer wall working machine is lifted or lowered by operation of the arm structure in a state where the outer wall working machine is held by the holding unit.

Preferred embodiments of the invention will be described below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings,

FIG. **1** is a perspective view showing an embodiment of a suspension support device for an outer wall working machine made according to the invention in a state suspending an outer wall working machine;

FIG. **2** is a plan view of the device of FIG. **1**;

FIG. **3** is a right side elevation of the device;

FIG. **4** is a front view of a holding unit;

FIG. **5** is a left side elevation of the holding unit shown in FIG. **4**;

FIG. **6** is a block diagram showing a control system;

FIG. **7** is an enlarged front view of connecting members of holding guides;

FIG. **8** is a left side elevation of the connecting members shown in FIG. **7**;

FIG. **9** is a sectional view taken along lines B—B in FIG. **7**;

FIG. **10** is a front view of the holding guides with the connecting members projecting to the lowermost position;

FIG. **11** is a sectional view taken along lines A—A in FIG. **4**;

FIG. **12** is a flow chart showing operation of the control system;

FIGS. **13A** and **13B** are views for explaining about postures of the device in positioning in the forward and rearward direction and a manner of detecting the position of the device in the forward and rearward direction;

FIG. 14 is a view for explaining about a manner of detecting a position of the device in a lateral direction in lateral positioning;

FIG. 15 is a view for explaining about a manner of detecting a position of the device in a lateral direction in lateral positioning;

FIG. 16 is a front view showing a state of connection by the connecting members;

FIG. 17 is a sectional view taken along line C—C in FIG. 16;

FIG. 18 is a side elevation of the holding guides showing a state where the outer wall working machine has been lifted excessively;

FIG. 19 is a schematic view showing a prior art suspension support device; and

FIG. 20 is a schematic view showing the suspension support device of FIG. 19 in a state holding an outer wall working machine in its holding unit.

DESCRIPTION OF PREFERRED EMBODIMENTS

A suspension support device **10** has a movable body **11** which is movable along rails **2** laid on a roof (upper surface **1A**) of a building **1**, a holding unit **20** connected to a pivotable arm **12** which constitutes the arm structure. An outer wall working machine **40** is suspended and supported by wire ropes **4** which are suspended vertically from the holding unit **20**.

The wire ropes **4** suspending the outer wall working machine **40** extend from a winding device **11D** provided in a rotary body **11B** of the movable body **11** through the inside of the pivotable arm **12** and inside of a lateral arm **21** of the holding unit **20** and are suspended from end portions of the lateral arm **21** and are connected to sides of the outer wall working machine **40** to support the working machine **40**.

The outer wall working machine in this embodiment is an automatic machine for automatically performing a window cleaning work. Although illustration of details of the working machine **40** is omitted, the working machine **40** has fitting and moving members **41** having plural rollers arranged in parallel on left and right end portions of a surface opposite to an outer wall surface **1B** of the building **1**. These fitting and moving members **41** can be fittedly engaged in vertical guide grooves **3** formed on the outer wall surface **1B** of the building **1**. As the rollers of the fitting and moving members **41** are rotated, the outer wall working machine **40** suspended by the wire ropes **4** is lifted or lowered, being guided along the guide grooves **3**.

The pair of the guide grooves **3** have an interval which is equal to a lateral interval of the pair of fitting and moving members **41**. The guide grooves **3** have a generally rectangular cross section with one side thereof opened outwardly like channel steel bars buried in the surface portion of the outer wall and the fitting and moving members **41** of the outer wall working machine **40** can be fittedly engaged in the guide grooves **3** in such a manner that the fitting and moving members **41** cannot move forward and rearward or leftward and rightward but can move vertically. The guide grooves **3** are formed at the upper edge portion of the building **1** with connecting openings **3A** having an upwardly increasing taper.

The suspension support device **10** will now be described more in detail.

The movable body **11** has a wheel unit **11C** which engages with the rails **2** laid on the upper surface **1A** of the building **1**, a running base **11A** including a drive mechanism (not shown) for driving the wheel unit **11C**, and the rotary body **11B** of a columnar configuration which constitutes the main body of the suspension support device **10** including the winding device **11D** for taking up and feeding out the wire ropes **4**. The rotary body **11B** is mounted on the running base **11A** rotatably about a vertical axis (first axis).

The rotary body **11B** is driven and rotated by a first axis motor **11E** (FIG. **3**) such as a servo motor including position and speed detectors. This first axis motor **11E** is, as shown in the control system of FIG. **6**, driven by a control system **30** and, therefore, the rotary body **11B** is driven and rotated by the control system **30**.

Driving of the wheel unit **11C** connected to the running base **11A** and the winding device **11D** provided in the rotary body **11B** are also controlled by the control system **30** and, therefore, the control system **30** controls movement of the movable body **11** along the rails **2** (i.e., movement of the suspension support device **10** along the rails **2**) and lifting and lowering of the outer wall working machine **40** by taking up and feeding out of the wire ropes **4**.

The pivotable arm **12** is pivotably supported about a vertical axis (second axis) at a portion in the vicinity of the upper peripheral portion of the rotary body **11B** and supports the holding unit **20** at the foremost end portion thereof. The base of the pivotable arm **12** is inserted in an opening of an arm holding portion **12B** provided on the rotary body **11B** and having a generally C-shaped cross section and is supported by the arm holding portion **12B** pivotably about the second axis in a horizontal plane. The pivotable arm **12** is rotated by a second axis motor **12A** such as a servo motor including position and speed detectors.

Driving of this second axis motor **12A** is controlled by the control system **30** and, therefore, the pivotable arm **12** is driven and rotated by the control system **30**.

The holding unit **20** includes the lateral arm **21** of a predetermined length and a pair of left and right holding guides **22** which constitute the holding guide members which extend vertically downwardly at an interval equal to the interval of the guide grooves **3** of the building **1**. The holding unit **20** is supported rotatably about a vertical axis (third axis) at the center of the lateral arm **21** on the foremost end portion of the pivotable arm **12**. The holding unit **20** is rotatable by a predetermined angle.

The lateral arm **21** is formed in the central portion thereof with a rearwardly projecting support portion **21A** which is supported on the foremost end portion of the pivotable arm **12** rotatably about the third axis and is rotated by a third axis motor **21B**.

Driving of this third axis motor **21B** is controlled by the control system **30** and, therefore, the holding unit **20** is rotated by the control system **30**.

The holding guides **22** are of a relatively small thickness and formed in a cross section which can be fittedly engaged in the guide grooves **3** and have a length which is sufficient for receiving the entire fitting and moving members **41**. Connecting members **23** are slidably provided in the lower end portion of the holding guides **22**.

The connecting members **23** each have, as shown in FIGS. **7**, **8** and **9**, an engaging main body **23A**, a connecting portion **23B** formed at the lower end of the engaging main body **23A** and having a tapered end portion corresponding to the upper end connecting openings **3A** of the guide grooves **3**, and a slide bar **23C** fixed on one side of the connecting members 23. The engaging main body 23A is slidably engaged with the outside surface of the holding guide 22 and the slide bar 23C is slidably engaged in a support guide 22A (FIG. 10) which is fixed on one side of the holding guide 22.

The slide bar 23C has an end stopper 23D fixed at its upper end and a stopper 23E fixed at a location nearer to the middle portion of the slide bar 23C. A coil spring 23F is provided outside of the slide bar 23C between the end stopper 23D and the stopper 23E. An actuating lever 23G in which the slide bar 23C is slidably engaged is provided between the lower end of the coil spring 23F and the stopper 23E and is urged by elastic restoring force of the coil spring 23F to the stopper 23E. The urging force of the coil spring 23F is set at a value which is larger than the entire weight of the connecting member 23 and, therefore, in a normal state, the connecting members 23 can be vertically moved by operating the actuating levers 23G vertically without deforming the coil springs 23F.

The engaging main bodies 23A of the connecting members 23 are slidably engaged with the holding guides 22 to be received on the holding guides 22 or project from the holding guides 22 as described above. The stroke of the sliding movement of the engaging main bodies 23A is so set that, when the engaging main bodies 23A are received on the holding guides 22 (i.e., in a withdrawn state), the lower end surfaces of the connecting portions 23B are located above the upper surface 1A of the building 1 by a predetermined distance as shown in FIGS. 4 and 5 whereas in a projecting state, the lower end surfaces of the connecting portions 23B are located, as shown in FIG. 10, below the upper surface 1A of the building 1 by a predetermined distance.

As shown in FIG. 11, the sliding drive of the connecting members 23 is achieved by actuation of the actuating lever 23G of the slide bar 23C by an actuator 42 projecting from the upper end portion on the rear surface of the outer wall working machine 40. More specifically, when the outer wall working machine 40 is to be held by the holding unit 20, the fitting and moving members 41 of the outer wall working machine 40 are engaged in the holding guides 22 of the holding unit 20 and the working machine 40 is lifted to a predetermined position. In the middle of this lifting movement, the actuators 42 of the working machine 40 interfere with the actuating levers 23G (i.e., the connecting members 23) and push up the actuating levers 23G (i.e., the connecting members 23). The sliding stroke is so set that, when the working machine 40 has reached a predetermined position and stops there, the connecting members 23 reach their upper limit position.

When the outer wall working machine 40 is lowered, the actuators 42 are lowered and, therefore, the connecting members 23 are also lowered due to their self-weight to project from the lower ends of the holder guides 22.

In the lower end portions of the holding guides 22, forward and rearward position detecting sensors 24, left and right position detecting sensors 25 and connecting member detection sensors 26 are provided on brackets 24A, 25A and 27, respectively.

Each of the forward and rearward position detection sensors 24 is constructed of a proximity switch and is supported on the bracket 24A fixed on the rear surface of the holding guide 22, facing downward to detect the upper surface 1A of the building 1. When the building 1 is located beneath the forward and rearward position detection sensor 24 (i.e., when the sensor 24 is above the building 1), the sensor 24 supplies a detection signal to the control system 30.

The left and right position detection sensors 25 are constructed of proximity switches and are supported on the brackets 25A fixed to the outer side surfaces of the holding guides 22, facing downward to detect the upper surface 1A of the building 1. When the building 1 is located beneath the left and right position detection sensors 25 (i.e., when the left and right position detection sensors 25 are above the building 1), the sensors 25 supply a detection signal to the control system 30.

The connecting member detection sensors 26 for each of the holding guides 22 consist of three proximity switches 26A, 26B and 26C and are arranged vertically at a predetermined interval on the bracket 27 fixed on the inner side surface of each holding guide 22, facing the the engaging main body 23A of the connecting member 23 to detect a projection 23H provided on the inner side of the engaging main body 23A of the connecting member 23. The sensor 26A is disposed at a position where it detects the projection 23H at the upper limit position of the connecting member 23 and serves as an upper limit detection sensor. The sensor 26B is disposed at a position where it detects the projection 23H when the lower end 23B of the connecting member 23 is engaged in the upper opening 3A of the guide groove 3 of the building 1 and serves as a connection detection sensor. The sensor 26C is disposed at a position where it detects the projection 23H at the lower limit position of the connecting member 23 and serves as a lower limit detection sensor. These sensors 26A, 26B and 26C respectively supply a detection signal to the control system 30 when they have detected the projection 23H.

By this arrangement, the control system 30 can detect the state of the connecting members 23 upon receipt of a projection 23H detection signal supplied from the connecting member detection sensors 26A, 26B and 26C. More specifically, when the lower limit sensor 26C has detected the projection 23H (i.e., when a detection signal has been supplied from the lower limit sensor 26C), the control system 30 can detect that the connecting member 23 projects from the holding guides 22 to their lower limit position as shown in FIG. 10 and the holding guides 22 are not located above the building 1 (i.e., there is no building 1 beneath the holder guides 22). When the connection sensor 26B has detected the projection 23H, the control system 30 can detect that the connecting portions 23B of the connecting members 23 are engaged in the connecting openings 3A of the guide grooves 3 of the building 1 (i.e., the holding guides 22 are aligned with the guide grooves 3) as shown in FIGS. 16 and 17. When the upper limit sensor 26A has detected the projection 23H, the control system 30 can detect that the connecting members 23 are received on the holder guides 22 to their upper limit position as shown in FIGS. 4 and 5.

The suspension support device 10 of the above described construction can hold the outer wall working machine 40 with its holding unit 20 and also can move the outer wall working machine 40 held by the holding unit 20 to any desired position within a range in which the pivotable arm 12 can reach on a horizontal plane by the movement of the movable body 11 along the rails 2, the rotation of the rotary body 11B about the first axis and the pivotal movement of the pivotable arm 12 about the second axis. The suspension support device 10 can further change the angle of the outer wall working machine on a horizontal plane as desired by the rotation of the holding unit 20 about the third axis. That is, the rotation drive mechanism for the rotary body 11B (the first axis motor 11E), the pivoting drive mechanism for the pivotable arm 12 (the second axis motor 12A) and the rotation drive mechanism for the holding unit 20 (the third axis motor 21B) as a whole constitute the arm structure drive means.

This arm structure drive means is driven, as described above, by the control system **30**. Lowering and lifting of the outer wall working machine **40** by taking up and feeding out of the wire ropes **4** by the winding device **11D** provided in the movable body **11** are also driven and controlled by the control system **30**.

The control system **30** controls the respective drive units of the suspension support device **10** in accordance with a predetermined program as described below to cause the fitting and moving members **41** of the outer wall working machine **40** to engage in the guide grooves **3** of the outer wall surface **1B** and lower and lift the working machine **40** along the guide grooves **3** for performing work on the outer wall surface **1B**.

The driving control of the suspension support device **10** by the control system **30** will now be described with reference to the flow chart shown in FIG. **12**.

First, the suspension support device **10** holding the outer wall working machine **40** is moved from its stand-by position along the rails **2** by driving the wheel unit **11C** of the movable body **11** (S1) and stopped at a predetermined position (S2). This stopping at a predetermined position is made by detecting a member to be detected provided on either one of the building **1** and the device **10** by a sensor provided on the other of the building **1** and the device **10**.

Then, the holding unit **20** is moved to perform positioning in the forward and rearward direction with respect to the outer wall surface **1B** (i.e., in the direction perpendicular to the outer wall surface **lB**) as well as positioning in the leftward and rightward direction (i.e., in the direction parallel to the outer wall surface **1B**).

For positioning of the holding unit **2** in the forward and rearward direction, the holding unit **20** is moved in the direction crossing the outer wall surface **1B** of the building **1** while maintaining the posture of the holding unit **20** by rotation of the rotary body **11B** about the first axis and pivoting of the pivotable arm **12** about the second axis and, during this movement, relative position of the holding unit **2** (position and angle) of the holding unit **20** with respect to the outer wall surface **1B** is detected in response to detection information concerning the outer wall surface **1B** by the forward and rearward position detection sensors **24** on the left and right sides (S3). On the basis of the detected relative position of the holding unit **20** with respect to the outer wall surface **1B**, the holding unit **20** is pivoted to a position parallel to the outer wall surface **1B** and the holding unit **20** is also moved forwardly or rearwardly while maintaining its posture to bring the holding unit **20** to a predetermined position (i.e., a position where the holding guides **22** are placed above a line extending leftward and rightward from the guide grooves **3**) (S4). In other words, as shown in FIGS. **13A** and **13B**, by moving the holding unit **20** forwardly or rearwardly while maintaining its posture, an inclination angle alpha of the holding unit **20** with respect to the outer wall surface **1B** and the position (coordinates) of the outer wall surface **1B** can be calculated from (1) difference Y in coordinates in the forward and rearward direction at which the forward and rearward position detection sensors **24** of the left and right sides has detected or ceased to detect the building **1** (i.e., the outer wall surface **1B**) and (2) the interval S between the two sensors **24**. On the basis of the detected inclination angle alpha and the coordinates of the outer wall surface **1B**, the holding unit **20** is pivoted about the third axis to a position at which the holding unit **20** is parallel to the outer wall surface **1B** and, as shown in FIG. **14**, the holding guides **22** of the holding unit **20** are brought to a position above the line extending leftward and rightward from the guide grooves **3** of the building **1** by rotation of the rotary body **11B** about the first axis and pivoting of the pivotable arm **12** about the second axis. In the state where the holding unit **20** has been positioned in the forward and rearward direction, the left and right position detection sensors **25** located at the sides of the holding guides **22** are also located above the line extending leftward and rightward from the guide grooves **3**.

For positioning of the holding unit **20** in the leftward and rightward direction, the holding unit **20** thus having been positioned in the forward and rearward direction is moved in parallel to the outer wall surface **1B** of the building **1** while maintaining its posture and coordinates in the leftward and rightward direction of the guide grooves **3** are detected in response to guide groove detection information by the left and right position detection sensors **25** (the guide grooves **3** can be detected by cease of detection of the building **1**) (S5). The holding guides **22** are moved in parallel in the leftward and rightward direction and stopped at a position where the holding guides **22** are aligned with the guide grooves **3** (S6). In other words, as shown in FIG. **14**, by moving the holding unit **20** in parallel to the outer wall surface **1B** of the building **1**, the left and right position detection sensors **25** provided at the sides of the holding guides **22** and facing downward cease, as shown in FIG. **15**, to produce a detection signal when its detection range has reached the guide grooves **3** and produces the detection signal again when the detection range has moved out of the guide grooves **3**. Therefore, by picking up a coordinate in the middle of a coordinate at which the detection signal has ceased and a coordinate at which the detection signal has been produced again, a coordinate of the center C.L of each guide groove **3** is obtained and the holding guides **22** are positioned so that the holding guides **22** are aligned with the center coordinate C. L of the guide grooves **3**.

After completion of the positioning of the holding unit **20** in the forward and rearward direction and the leftward and rightward direction and resulting alignment of the holding guides **22** with the guide grooves **3**, the winding device **11D** is operated to feed out the wire ropes **4** and thereby to lower the outer wall working machine **40** (S7).

As the outer wall working machine **40** is lowered, the connecting members **23** project from the lower ends of the holding guides **22** and, in advance to the movement of the fitting and moving members **41**, the connecting portions **23B** of the connecting members **23** are engaged in the connecting openings **3A** of the guide grooves **3** as shown in FIGS. **16** and **17** whereby the holding guides **22** are connected with the guide grooves **3** via the connecting members **23**. Whether or not the connecting portions **23B** of the connecting members **23** are correctly engaged in the connecting openings **3A** of the guide grooves **3** is judged by a detection signal from the connection sensor **26B** (S8). More specifically, when a projection **23H** detection signal is supplied from the connection sensor **26B**, the routine proceeds to a next step on the assumption that the connecting portions **23B** of the connecting members **23** are correctly engaged in the connecting openings **3A** of the guide grooves **3** whereas when the projection **23H** detection signal is not supplied from the connection sensor **26B**, it is assumed that the connecting portions **23B** of the connecting members **23** are not engaged in the connecting openings **3A** of the guide grooves **3** and the lowering of the outer wall working machine **40** is stopped (S9) and then the outer wall working machine **40** is lifted to a predetermined position (S10) and held in the stand-by state by the holding unit **20** (S11). Then, the positioning routine is repeated from the above described step S3.

When the projection **23H** detection signal is supplied from the connection sensor **26B** and it is thereby judged that the connecting portions **23B** of the connecting members **23** are engaged in the connecting openings **3A** of the guide grooves **3**, lowering of the outer wall working machine **40** is continued and, when the outer wall working machine **40** has reached a position facing the outer wall surface **1B** of the building **1**, the outer wall working machine **40** starts work on the outer wall surface **1B** (S12) and continues the work by continuing lowering.

When the outer wall working machine **40** has reached the lower end of the building **1**, the work and lowering of the outer wall working machine **40** are stopped (S13, S14) and the outer wall working machine **40** is lifted (S15) and held by the holding unit **20** (S16). The routine returns to the step Si and, by driving of the movable body **11**, the suspension support device **10** is moved to a next work area to repeat the positioning and subsequent processings.

For holding of the outer wall working machine **40** by the holding unit **20**, the outer wall working machine **40** is lifted and the fitting and moving members **41** thereof move from the guide grooves **3** of the building **1** to the holding guides **22** via the connecting members **23** and thereafter the actuators **42** of the outer wall working machine **40** abut against the actuating levers **23G** of the slide bars **23C**. As the outer wall working machine **40** is lifted further, the actuating levers **23G** (i.e., the connecting members **23**) are pushed up by the actuators **42** and, accordingly, the connecting ends **23B** of the connecting members **23** are brought out of engagement with the upper openings **3A** of the guide grooves **3**. When the outer wall working machine **40** is lifted to a predetermined position, as shown in FIGS. **4** and **5**, the outer wall working machine **40** is received on the holding guides **22** and there is provided a predetermined interval between the lower surface of the connecting ends **23B** and the upper surface **1A** of the building **1**. Therefore, the connecting members **23** do not interfere with the building **1** and do not prevent movement of the suspension support device **10**. When the outer wall working machine **40** is lifted beyond the predetermined position for some reason, the connecting members **23** cannot be lifted further because this predetermined position is the upper limit position of the connecting members **23**. In this case, as shown in FIG. **18**, the actuating levers **23G** slide against the slide bars **23C** by compressing the coil springs **23F** whereby application of an excessive upward force to the connecting members **23** can be prevented.

When rotation of the rotary body **11B** about the first axis, pivoting of the pivotable arm **12** about the second axis and rotation of the holding unit **20** about the third axis are carried out in the state where the outer wall working machine **40** is held by the holding unit **20**, there can be a case where length of wire ropes **4** change slightly depending upon design of the device **10** but in this case also, the outer wall working machine **40** will be permitted to be lifted or lowered to cope with such change of the length of the wire ropes **4** owing to elastic deformation of the coil springs **23F**.

In the above described embodiment, for moving the holding unit **20** in the forward and rearward direction as well as in the leftward and rightward direction, the rotary body **11B** is rotated about the first axis, the pivotable arm **12** is

pivoted about the second axis, and the holding unit **20** is rotated about the third axis with respect to the pivotable arm **12**. The structure of the holding unit **20**, however, is not limited to this but it may be other structure if the holding unit **20** can be moved while maintaining its posture in the forward and rearward direction as well as in the leftward and rightward direction. For example, a stretchable arm may be provided on the rotary body **11B** and the holding unit **20** may be supported at the foremost end thereof in such a manner that the holding unit can be pivoted about a vertical axis.

In the above described embodiment, the independent sensors (i.e., forward and rearward position detection sensors **24** and left and right position detection sensors **25**) are provided for detecting the forward and rearward position and the leftward and rightward position of the holding unit **20**. The arrangement of the sensors is not limited to this but a single sensor may be used commonly for detecting the forward and rearward position and the leftward and rightward position of the holding unit **20**.

What is claimed is:

1. A suspension support device provided movably on the upper surface of a building for suspending, by means of ropes, an outer wall working machine having fitting and moving members which can be fittedly engaged in a pair of guide grooves formed vertically on an outer wall surface of the building, and lowering and lifting the outer wall working machine along the guide grooves comprising:

a main body;

an arm structure connected to the main body;

a holding unit connected to the arm structure in a manner to be movable forwardly and rearwardly, laterally and pivotable about a vertical axis and including a pair of holding guide members provided at an interval equal to an interval of the pair of guide grooves and being capable of receiving the fitting and moving members;

arm structure drive means for driving the arm structure to move the holding unit;

sensor means provided at both sides of the holding unit at positions corresponding to the holding guide members for detecting the upper edge of the building; and

drive control means for controlling driving of the arm structure drive means in response to detection information supplied by the sensor means,

said drive control means controlling driving of the arm structure to move the holding unit in a direction perpendicular to the outer wall surface while maintaining the posture of the holding unit, calculate angle and position of the holding unit with respect to the outer wall surface in response to the detection information concerning the outer wall surface supplied by the sensor means, move the holding unit to a position which is parallel to the outer wall surface and coincidental with the guide grooves in a direction perpendicular to the outer wall surface and thereafter move the holding unit in a direction parallel to the outer wall surface in a horizontal plane while maintaining the posture of the holding unit and, responsive to the detection information concerning the guide grooves supplied by the sensor means, bring the holding unit to a position at which the holding guide members align with the guide grooves.

2. A suspension support device as defined in claim 1 wherein the lower ends of the holding guide members of the

holding unit are spaced from the upper edge of the building by a predetermined distance and said holding unit further comprises connecting members provided vertically slidably in the lower portion of the holding guide members to project from and withdraw into the holding guide members and thereby connect and disconnect the holding guide members with the guide grooves of the building and said holding unit further comprises actuator means connected to the connecting members, said connecting members being withdrawn into the holding guide members by operation of the actuator means by the outer wall working machine when the outer wall working machine is lifted and held by the holding guide members and said connector members projecting from the holding guide members when the outer wall working machine is lowered from the holding guide members to the outer wall surface of the building and thereby connecting the holding guide members with the guide grooves.

3. A suspension support device as defined in claim **2** wherein said holding unit further comprises a spring provided between the connecting members and the actuator means for permitting, by elastic deformation of the spring, vertical movement of the outer wall working machine in a state where the connecting members are withdrawn and received in the the holding guide members.

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